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IMPACT ASSESSMENT REPORT

ANNEXES

Accompanying the proposal for a

Directive of the European Parliament and of the Council

on Soil Monitoring and Resilience (Soil Monitoring Law)

{COM(2023) 416 final} - {SEC(2023) 416 final} - {SWD(2023) 416 final} - {SWD(2023) 418 final} - {SWD(2023) 423 final}

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ANNEX 7: PROBLEM DEFINITION

1 MAIN PROBLEM

The main problem that the Soil Health Law intends to address can be stated as follows:

Soils in the EU are unhealthy and continue to degrade.

Scientific evidence indicates that soil degradation in the EU is continuing and worsening. About 60 to 70% of soils in the EU have been estimated currently not in a healthy state.[1]

Data on a series of problem areas is presented in the following sections.

1.1 Soils in the EU are subject to soil loss.

Soil loss takes two forms: soil erosion and mineralisation of organic soil (specifically in peatlands).

Soil **erosion** consists of the removal of soil, generally at its surface, in the layer known in soil science as the 'A horizon' that is the most fertile and productive soil layer in agricultural land. Soil erosion takes place because of natural phenomena or by human action. Erosion is considered unsustainable when it removes soil at a rate that is superior to the soil formation rate.

The main causes of soil erosion are:

- Erosion caused by natural phenomena:
  - Water erosion;
  - Wind erosion;
- Erosion caused directly by human action:
  - Harvest erosion;
  - Tillage erosion.

Each of these problems is described in greater detail below.

The mineralisation of organic soils occurs when they are drained for agriculture or forestry, resulting in soil subsidence that can result in a drop of land surface by several meters. This happens because organic soils have extremely low density and high porosity or saturated water content.

1.1.1 Water erosion

Water erosion of soils occurs through four predominant processes:

- splash erosion – where small soil particles can be moved by the impact of a falling raindrop;
- sheet wash – whereby surface soil is removed in thin layers by shallow flows of water;
- rill erosion – whereby small channels are formed on the soil surface by concentrated overland flow of water, and

[1] European Commission, Directorate-General for Research and Innovation, Veerman, C., Pinto Correia, T., Bastioli, C., et al., *Caring for soil is caring for life : ensure 75% of soils are healthy by 2030 for food, people, nature and climate : report of the Mission board for Soil health and food*, Publications Office, 2020, https://data.europa.eu/doi/10.2777/821504

- gullies – which transport soil particles through large channels that carry water only for brief periods.[2]

Water erosion is favoured by intense rainfall on bare soils. Bare soils are one of the consequences of (1) conventional agricultural practices that often leave soils unprotected due to the absence of vegetation during a significant portion of the year, (2) droughts and (3) wildfires. All these circumstances favouring water erosion of soil are becoming more frequent and more severe because of climate change.

Around 12 million hectares of agricultural land (including pastures), i.e. 6.58% of EU agricultural area, are under threat of severe water erosion, i.e. erosion at a rate higher than 10 t/ha/yr.[3] Research by Panagos et al. (2015)[4] reported that 24% of EU countries exhibit unsustainable soil water erosion rates, i.e. erosion rates above 2 t/ha/yr that exceed the soil formation rates. This covers a wide range of land use types, but 70% occurs on land in agricultural systems. The same study also estimated that the average annual soil loss due to water was approximately 2 t/ha in 2010 and 3 t/ha in 2016. The study considered only ‘erosion prone’ areas for the analysis, consisting of agricultural, forest and semi-natural areas, estimating this area as succumbing to approximately 970 million tonnes of soil loss due to water erosion in 2016.[5]

The total estimated soil loss by water erosion per annum in the EU+UK is between 950 to 970 million tonnes.[6] Ultimately, the continued rate of unsustainable erosion rates can result in negative impacts on crop production, water quality degradation (turbidity, excess nutrients) in downstream water bodies, drinking water production possibilities and costs (water filtration and retention capabilities of soil), siltation of dams and waterways, biodiversity and carbon storage.

1.1.2 Wind erosion

Wind erosion occurs in dry conditions when the soil is exposed to wind. It is a wind-forced movement of soil where the finest particles, particularly organic matter, clay and loam, are entrained and transported over long distances before being redeposited elsewhere.

Particles of soil are eroded by the wind through three predominant processes: surface creep, saltation and suspension. Surface creep entails the rolling/sliding of particles/soil aggregates along the surface, typically impacting larger particles/aggregate dimensions. Saltation involves particles suspended and then bounced along the surface- causing the breakdown of particles and potentially liberating other materials prone to suspension. Suspension can hold small particles airborne for several thousand kilometres before they are deposited.[7]

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[2] Panos Panagos et al. “The new assessment of soil loss by water erosion in Europe,”, Environmental Science & Policy, Volume 54, 2015, Pages 438-447, https://doi.org/10.1016/j.envsci.2015.08.012 .
3 JRC ecosystem assessment (2020) - Chapter on Soil https://publications.jrc.ec.europa.eu/repository/handle/JRC120383.
[4] Panagos et al. (2015) The new assessment of soil loss by water erosion in Europe.
[5] See footnote 5; Panagos et al., (2021). Projections of soil loss by water erosion in Europe by 2050.
[6] Panagos et al., (2021) Projections of soil loss by water erosion in Europe by 2050; EEA (2019) The European environment — state and outlook 2020.
[7] Acosta-Martinez et al., (2015) Microbiology of wind-eroded sediments: Current knowledge and future research directions.

The movement of soils by wind occurs when three environmental conditions occur: the wind is strong enough to mobilize soil particles; the texture, organic matter and moisture of soil make it vulnerable to wind erosion; and the surface lacks vegetation, stones or snow.[8]

In recent times, intensive farming has increased the frequency and magnitude of this geomorphic process with consequences especially for sensitive lands, important for food production. Land management practices such as intensive crop cultivation, increased mechanisation, enlargement of field sizes, removal of hedges, high residues/biomass exploitation of vegetation and consecutive bare fallow years in cultivated lands exacerbated both environmental and economic effects of wind erosion.[9]

Soil erosion by wind is a significant issue in some areas, often resulting in severe soil degradation through reduction in nutrient levels, organic matter content, water holding capacity, chemical fertility, and biodiversity.[10,11] Soil loss due to wind diminishes the ability of soils to support vegetation, by removing the most fertile, nutrient-rich topsoil layer.[12] The impacts of this process can also endure far beyond on-site erosion impacts, as wind borne particles of silt and dust can also transport pollutants – causing off-site soil contamination and impacting air and water quality[13,14] yet the scale and impacts of wind erosion vary significantly between MSs.

Such erosion has always existed, yet current anthropogenic pressures (from, inter alia, agricultural and forestry practices)[15] and climate change are exacerbating erosion rates.[16] Studies have estimated that of the total global dust emissions, 10% is derived from agricultural sources.[17] In Europe, areas which were previously analysed as minimally impacted are now encountering significant wind erosion issues.[18] Overall, wind erosion is estimated to impact up to 42 million hectares of European agricultural land.[19] However, the scale and impacts of wind erosion vary significantly between MSs. This was demonstrated by Riksen and de Graaff (2001),[20] who estimated wind erosion affected up to 38% of the utilised agricultural area in Denmark and 5.2% in the Netherlands. On average, it is estimated across EU+UK that annual soil loss on arable land due to wind erosion was approximately 0.53 t/ha/yr, with the highest wind erosion rates reaching up to 2 t/ha/yr.[21]

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8 Borelli et al., (2014) Wind erosion susceptibility of European soils.
9 Borrelli, P., Lugato, E., Montanarella, L., and Panagos, P. (2017) A New Assessment of Soil Loss Due to Wind Erosion in European Agricultural Soils Using a Quantitative Spatially Distributed Modelling Approach. Land Degrad. Develop., 28: 335– 344. doi: 10.1002/ldr.2588.
10 Stolte et al., (2016) Soil threats in Europe.
Available at: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/doc_pub/EUR27607.pdf
11 Borelli et al., (2017) A New Assessment of Soil Loss Due to Wind Erosion in European Agricultural Soils Using a Quantitative Spatially Distributed Modelling Approach.
12 Lackoova et al., (2021) Long-Term Impact of Wind Erosion on the Particle Size Distribution of Soils in the Eastern Part of the European Union.
13 Borelli et al., (2017) A New Assessment of Soil Loss Due to Wind Erosion in European Agricultural Soils Using a Quantitative Spatially Distributed Modelling Approach.
14 Stolte et al., (2016) Soil threats in Europe.
Available at: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/doc_pub/EUR27607.pdf
15 Borelli et al., (2014) Wind erosion susceptibility of European soils
16 Lackoova et al., (2021) Long-Term Impact of Wind Erosion on the Particle Size Distribution of Soils in the Eastern Part of the European Union
17 Tegen et al., (2004) Relative importance of climate and land use in determining present and future global soil dust emission
18 Stolte et al., (2016) Soil threats in Europe.
Available at: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/doc_pub/EUR27607.pdf
19 JRC (2022) Wind Erosion. Available at: https://esdac.jrc.ec.europa.eu/themes/wind-erosion
20 Riksen and De Graaff (2001) On-site and off-site effects of wind erosion on European light soils.
21 Borelli et al., (2017) A New Assessment of Soil Loss Due to Wind Erosion in European Agricultural Soils Using a Quantitative Spatially Distributed Modelling Approach.

As in the case of agriculture, wind erosion in forests is exacerbated by land management actions that lead to a reduction on ground cover (e.g. logging), in addition to wildfires occurrence. Across the EU, high soil loss potential was identified in several MS, including parts of Spain, Italy, Cyprus, Slovenia, Greece and Austria. The EU+UK average area-specific soil loss in forests is estimated at 0.11 t/ha/yr.[22] Notably, 26.6% of the soil loss was predicted to occur in the disturbed forest areas although these areas covered only around 7.1% of the EU+UK forestland area.[23] Similarly, a specific assessment undertaken in Italy based on monitoring and modelling showed that almost half of the soil loss (45.3%) was predicted for the logged areas, even though these represent only about 10.6% of the Italian forests.[24]

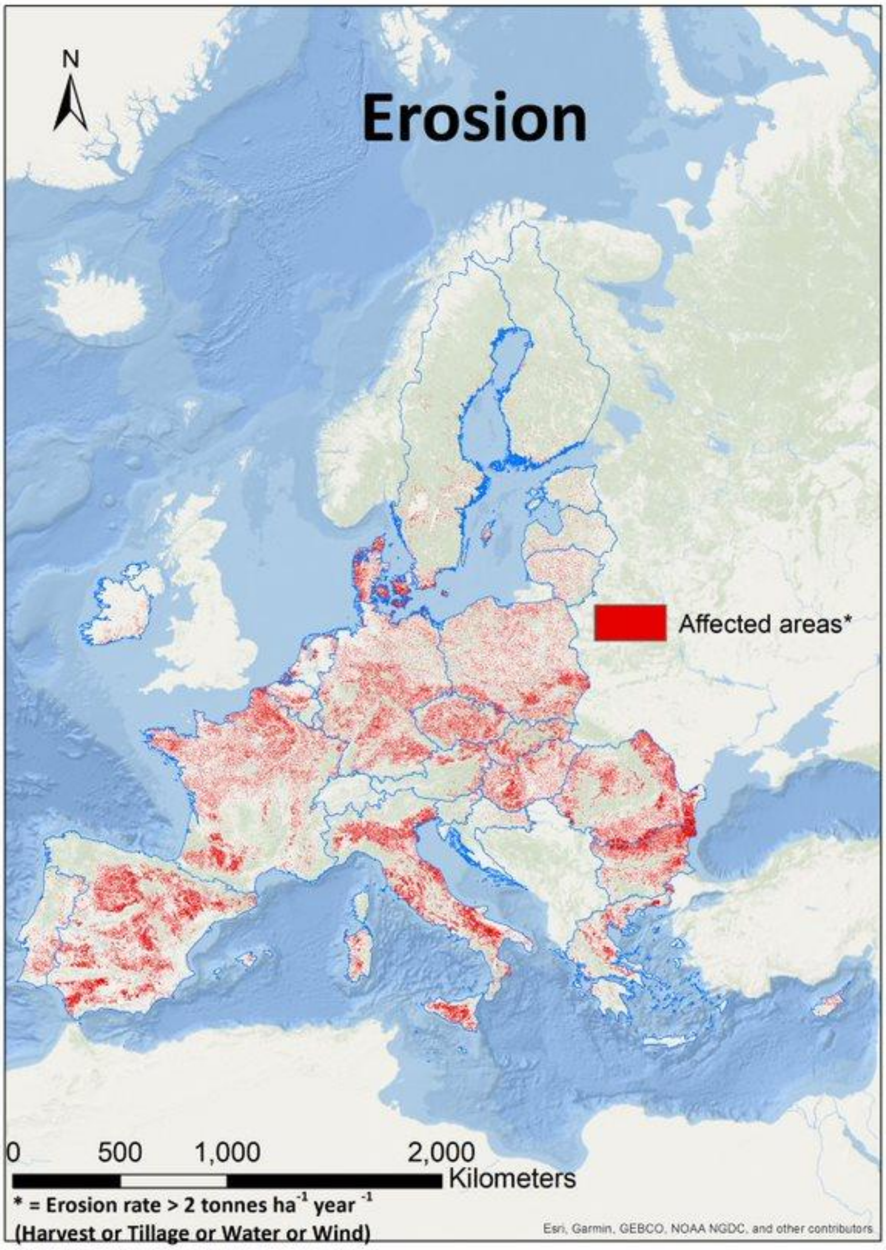
1.1.3 Soil loss by crop harvesting

Soil Loss due to Crop Harvesting is defined as the loss (or export) of topsoil from arable land during harvesting of root and tuber crops (e.g. potato, sugar beet, carrot, chicory roots). During the harvest, soil sticks to the crop and is removed from the fields.[25] In addition, this form of soil loss depends much on the soil disturbance during the harvest operation. Several factors control the magnitude of soil loss by harvesting as well as their soil loss rates. The most important factors are: i) soil characteristics (e.g. soil moisture, soil texture, soil organic matter and soil structure), ii) the crop type, iii) the agronomic practices (e.g. plant density, crop yield), and iv) the harvest techniques (technology, effectiveness and velocity of harvester).

During the period 2000-2016, the total Soil Loss by Crop Harvesting is estimated at ca. **14.7 million t/yr** in the EU-28, i.e. **0.13 t/ha/yr**. Ca. 65% of the total SLCH is due to harvesting of sugar beets and the rest as a result of potatoes harvesting. In the period 1986-1999 the total SLCH was ca. 23.4 million t/yr, displaying a decrease by 37% between 1986-99 and 2000-2016 is due to a sharp decrease in sugar beet production. Despite its low average value at the scale of the EU, SLCH is concentrated in some regions, specifically North-East France, where the production of sugar beet is more intense, reaching values above 0.3 t/ha/yr.[26]

The following map produced by the Joint Research Centre (JRC) presents the areas with estimated erosion (combining the different erosion factors) beyond 2 t/ha/yr.

[22] Borrelli et al., (2016) Assessment of the cover changes and the soil loss potential in European forestland: First approach to derive indicators to capture the ecological impacts on soil-related forest ecosystems.
Available at: https://www.sciencedirect.com/science/article/pii/S1470160X1500494X
[23] See footnote 22.
[24] European Soil Data Centre (ESDAC) (n.d.) Erosion in forestland. Available at: https://esdac.jrc.ec.europa.eu/themes/erosion-forestland
[25] Ruysschaert et al., (2004). Soil loss due to crop harvesting: significance and determining factors.
[26] Panos Panagos,et al. “Soil loss due to crop harvesting in the European Union: A first estimation of an underrated geomorphic process”, Science of The Total Environment, Volume 664, 2019, Pages 487-498, https://doi.org/10.1016/j.scitotenv.2019.02.009 .



1.1.4 Mineralisation of organic soils

Organic soils are those containing a high concentration of organic matter. They are defined by the IPCCC as follows.[27] Soils are organic if they satisfy requirements 1 and 2 such as a land area under cultivation, or 1 and 3 such as a wetland area:

1. The soil must have a depth of 10 cm or more. A horizon less than 20 cm deep must contain 12% or more organic carbon when mixed to a depth of 20 cm.
2. The soil is never saturated with water for more than a few days and must contain more than 20% (by weight) organic carbon (about 35% organic matter).
3. The soil must be subject to periods when it is saturated with water and have:

[27] IPCC, 2006, 2006 IPCC guidelines for national greenhouse gas inventories, Intergovernmental Panel on Climate Change. (https://www.ipcc.ch/report/2006-ipcc-guidelines-for national-greenhouse-gas-inventories/)

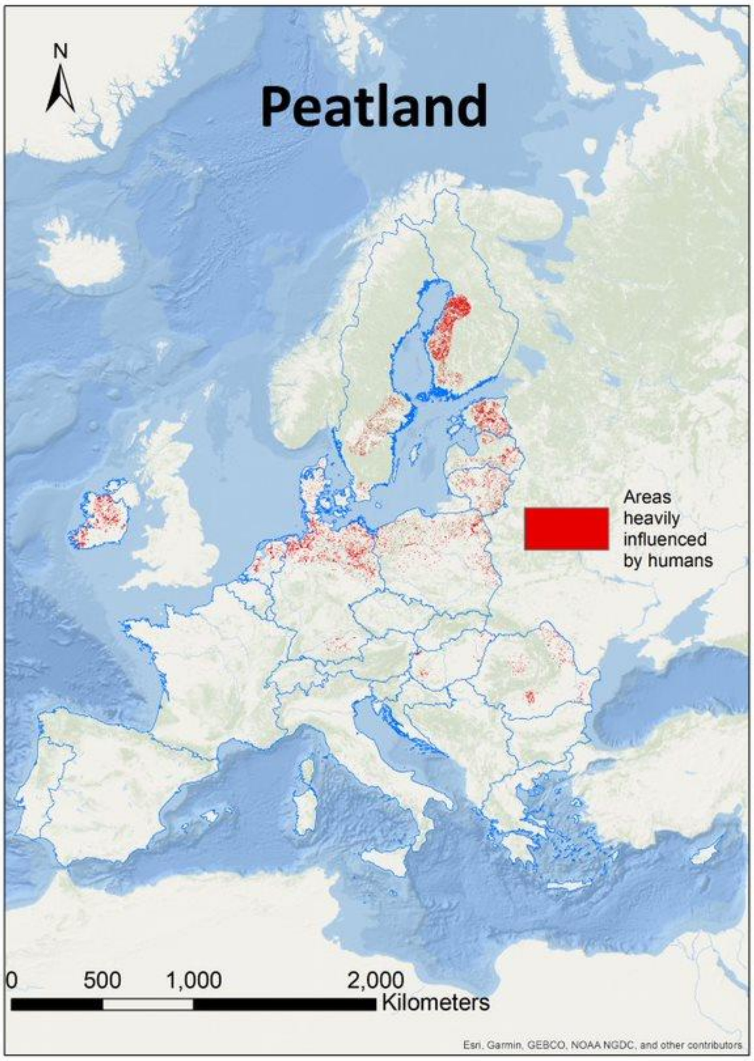
a. at least 12% (by weight) organic carbon (about 20% organic matter) if it has no clay; or
b. at least 18% (by weight) organic carbon (about 30% organic matter) if it has 60% or more clay; or
c. an intermediate, proportional amount of organic carbon for intermediate amounts of clay.

A soil that is not organic is considered as mineral.

Organic soils represent 7.9% of land area, of which 4.2% is managed (i.e. used by human activities), while the remaining 3.7% are not, and constitute wetlands.[28] A significant share of organic wetlands is made of peatlands. Peatlands are ecosystems with a unique type of peat soil formed from plant material that has only partially decomposed due to water saturated soil conditions (and in polar areas also due to the cold). While they are relatively rare, covering around 3-4% of the planet's land surface, they contain up to one third of the world's soil carbon (in the range of 450,000 to 650,000 megatons (Mt)). This is twice the amount of carbon as found in the entirety of Earth's forest biomass.[29]

The following map produced by the JRC presents the areas with peatlands heavily influenced by human activity.

[28] EEA – Briefing on soil carbon. https://www.eea.europa.eu/publications/soil-carbon.
[29] UNEP (2022). Global Peatlands Assessment – The State of the World's Peatlands: Evidence for action toward the conservation, restoration, and sustainable management of peatlands. Main Report. Global Peatlands Initiative. United Nations Environment Programme, Nairobi. Accessible at: https://www.unep.org/resources/global-peatlands-assessment-2022 .



Mineralisation of organic soils is caused by:

- Their drainage, performed in order to grow agricultural crops, support agricultural machines or livestock or forests or its physical removal for fuel or use in horticultural processes;
- Climate change, which increases temperatures and generates lengthy and deep droughts affecting also these traditionally humid areas.

Mineralisation of organic soils leads to a subsidence of the soil surface, at a rate between 5.15 and 9.47 mm/yr for riparian peatland on the west coast of Finland,[30] and to a loss of 10 to 20 tonnes of carbon ha/yr.[31] The total peatland surface susceptible to mineralisation in the EU covers 229,000 km^2, mainly in the Nordic countries (Finland, Sweden), but also in Poland, Germany, the Netherlands and Ireland.

[30] Ikkala et al., (2021) Peatland subsidence enhances cultivated lowland flood risk.
[31] RECARE project – Organic matter decline in peatlands, accessible at: https://www.recare-hub.eu/images/articles/Soil_Threats/OM_loss_peat/FactSheet_OM_loss_peat_Final.pdf

1.2 Soils in the EU are subject to land take

1.2.1 Land take

Land take represents the conversion of natural or semi-natural land to artificial land, for the sake of constructing housing, infrastructure, office buildings, factories, warehouses and logistics centres or parking spaces.

Data shows that despite reductions in the past decades, land take is still represents a substantial proportion of land in the EU. In 2018, artificial land covered 174,792 km^2 of soil in the EU-28, representing 4.2% of its total land surface.[32]

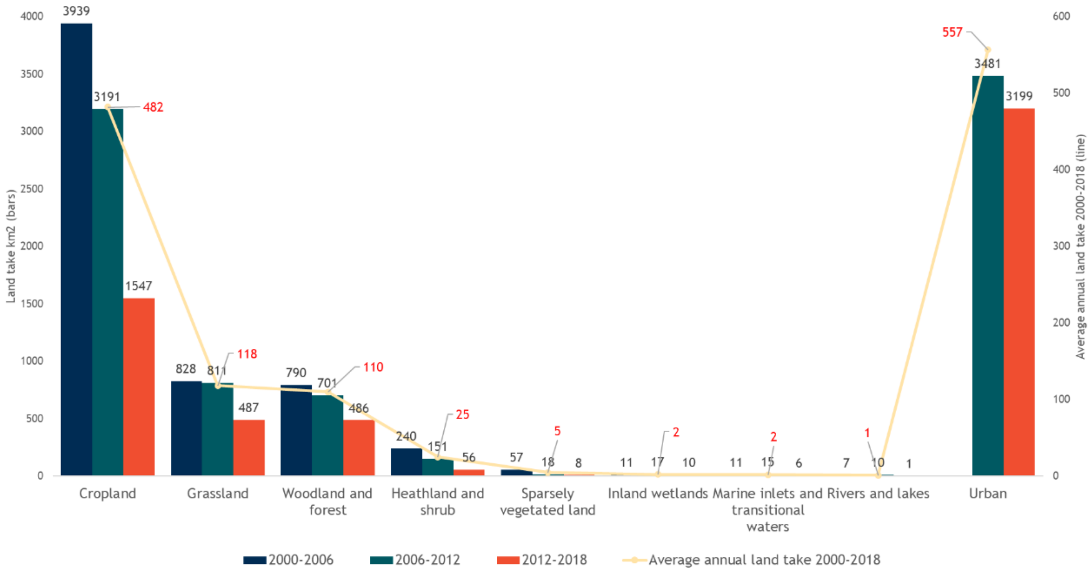
Land take has essentially occurred at the expense of urban areas and of croplands, for surfaces of 8,678 km^2 and 6,680 km^2 respectively since 2000. Land take surrounding urban areas is mostly at the expense of croplands and pastures, indicating that the spread of urban areas is replacing some of Europe's most significant biodiversity hotspots, carbon sinks, and food production areas.[33] When considering net land take (i.e. land take from which land return to non-artificial land categories is subtracted), it appears that this net land take remains strongly positive, as ten times more land has been taken (approximately 12,000 km^2) than recultivated (1,200 km^2) between 2000 and 2018.[34] It should be noted in addition that re-cultivated land sometimes involves land being taken from natural peatlands – hence with an overall negative impact on climate change.

Figure 1-1 highlights land take in the EU-27 between 2000-2018 (data only available from 2006 for urban ecosystems) according to the MAES ecosystem classification. Between 2000 and 2018, net land take in the EU-27+UK reached over 13,000 km^2. Between 2000 and 2018, 78% of land take in the EU-28 affected agricultural areas (i.e. arable lands and pastures, and mosaic farmlands). This amounted to a loss of 394.34 km^2/yr of arable lands and permanent crops (or a loss of 0.6% of all arable lands and permanent crops during that period), and to a loss of 212.44 km^2/yr of pastures and mosaic farmlands (or a loss of 0.5% of all pastures and mosaic farmlands).[35]

Land taken by urban areas and infrastructure is generally irreversible and can result in the loss of soil ecosystem services due to covering the land for housing, roads or industry.[36] The increase in artificial surfaces often impairs or disrupts valuable ecological functions of soils, notably biomass provision, its capacity to host soil biodiversity and store carbon, and water infiltration potential, with negative implications for climate change mitigation and adaptation (e.g., due to increased runoff during flood events).[37] Furthermore, land take can often lead to the loss of productive (i.e. agricultural and forest soils), further straining demand for productive soils.[38]

[32] EUROSTAT (2021) Land covered by artificial surfaces by NUTS 2 regions.
Available at: https://ec.europa.eu/eurostat/databrowser/view/lan_lcv_art/default/table?lang=en
[33] EEA (2021) Land take and land degradation in functional urban areas. EEA report 17/2021.
[34] EEA (2022) Land take and net land take, Land take statistics by country.
Available at: https://www.eea.europa.eu/data-and-maps/dashboards/land-take-statistics#tab-based-on-data.
[35] https://www.eea.europa.eu/data-and-maps/indicators/land-take-3/assessment
[36] EEA (2022) Land take and net land take, Land take statistics by country.
Available at: https://www.eea.europa.eu/data-and-maps/dashboards/land-take-statistics#tab-based-on-data.
[37] EEA (2019) The European environment — state and outlook 2020 Knowledge for transition to a sustainable Europe.
[38] Virto et al., (2015) Soil Degradation and Soil Quality in Western Europe: Current Situation and Future Perspectives.

Figure 1-1: Land take (km2) in EU-27 by MAES ecosystem, from 2000 to 2018 (primary y-axis), and total area of land take (secondary y-axis and yellow line, red text)



Source: EEA (2022) Land take and net land take, Land take statistics by country.

Available at: https://www.eea.europa.eu/data-and-maps/dashboards/land-take-statistics#tab-based-on-data. Urban data taken from EEA (2022) Land take in Functional Urban Areas, 2012-2018. Available at: https://www.eea.europa.eu/data-and-maps/data/data-viewers/land-take-in-functional-urban .

Legend: The yellow line (with red text legend) highlights the average annual land take per ecosystem.

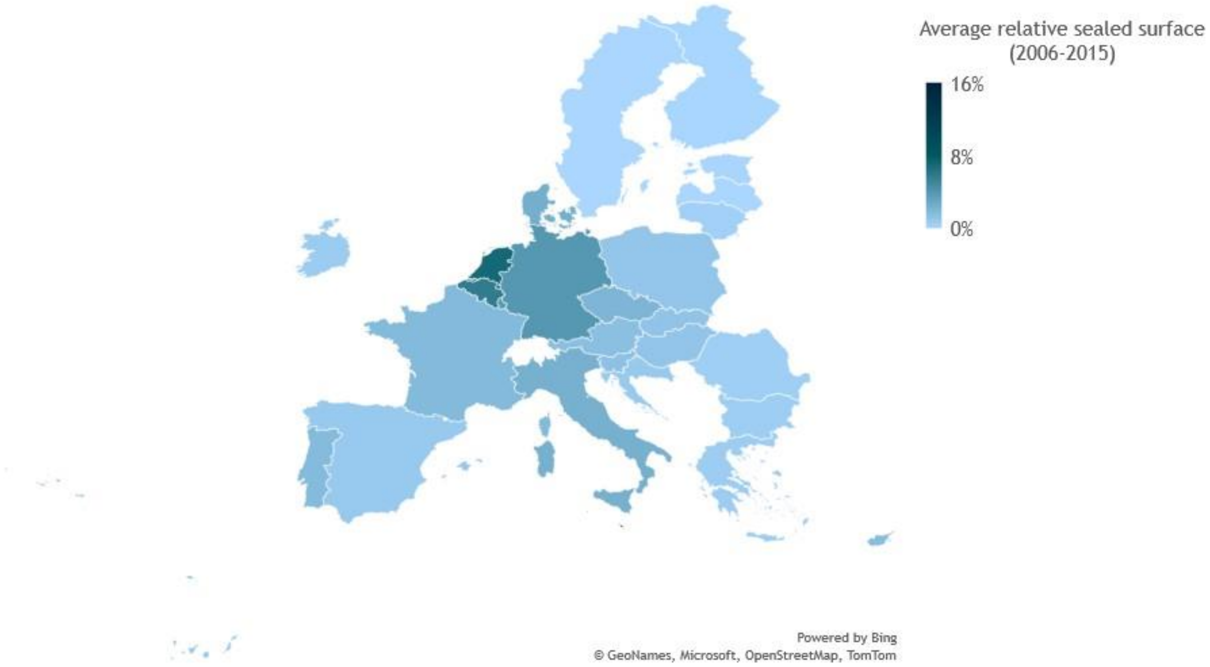
1.2.2 Soil sealing

Land take is particularly problematic when coinciding with soil sealing (which can be classified as the most intense form of land take). Defined as "the destruction or covering of soils by buildings, constructions and layers of completely or partly impermeable artificial material",[39] soil sealing is the extreme form of land artificialisation, and causes a substantial loss of soil ecosystem services.[40,41] In the EU-27, the latest data (2015) indicates that over 77,000 km^2 (1.77% of total terrestrial area) of land in the EU-28 is sealed.[42] Soil sealing has increased by 78% since the 1950s/[43] The average absolute EU-27 area of soil sealed between 2006-2015 was approximately 332 km^2 per year, reaching a cumulative area of 2,989 km^2. Nevertheless, the absolute total area of soil sealing between this time period has decreased in intensity, from 1188 km^2 between 2006-2009 (annual average of 396 km^2) to 639 km^2 in 2012-2015 (annual average of 213 km^2), reaching an EU total artificial surface area of 174,792 km^2.[44]

[39] Petra Stankovics, Luca Montanarella, Piroska Kassai, Gergely Tóth, Zoltán Tóth, "The interrelations of land ownership, soil protection and privileges of capital in the aspect of land take", Land Use Policy, Volume 99, 2020, https://doi.org/10.1016/j.landusepol.2020.105071
[40] RECARE-HUB (2018) What is Soil Sealing?
Available at: https://www.recare-hub.eu/soil-threats/sealing#what_is_soil_sealing
[41] EEA (2019) The European environment — state and outlook 2020 Knowledge for transition to a sustainable Europe
[42] EEA (2019) Imperviousness in Europe.
Available at: https://www.eea.europa.eu/data-and-maps/dashboards/imperviousness-in-europe
[43] EEA (2022) What is soil sealing and why is it important to monitor it?
Available at: https://www.eea.europa.eu/help/faq/what-is-soil-sealing-and
[44] EUROSTAT (2021) Land covered by artificial surfaces by NUTS 2 regions.
Available at: https://ec.europa.eu/eurostat/databrowser/view/lan_lcv_art/default/table?lang=en

Large discrepancies exist between MSs, where soil sealing in relation to MS land surface area, as shown in Figure 1-2, highlights that MSs such as Malta (16%), Netherlands (7%) and Belgium (6%) have sealed areas significantly above the EU-27 average between 2006-2015 (2.5%).[45]

Figure 1-2: EU-27 relative sealed surface area 2006-2015.



Source: Data taken from EEA (2019) Imperviousness in Europe.
Available at: https://www.eea.europa.eu/data-and-maps/dashboards/imperviousness-in-europe.

The following map produced by the JRC presents the areas with soil sealing

[45] See footnote 42.

1.3 Other soil degradations

In this section, the physical, chemical and biological aspects of the degradation of soil health are listed, and then, for each of these aspects, describe the magnitude of this degradation in the EU.

In its report of 2020, the Soil Mission Board concluded that "current management practices result in, approximately, 60-70% of EU soils being unhealthy with a further as yet uncertain percentage unhealthy due to poorly quantified pollution issues".[46] Table 1-1 below summarises the share of EU land subject to each category of degradation identified

[46] Veerman, C., Correia, T. P., Bastioli, C., Biro, B., Bouma, J., Cienciala, E., ... & Wittkowski, R. (2020). Caring for soil is caring for life: ensure 75% of soils are healthy by 2030 for healthy food, people, nature and climate: interim report of the mission board for soil health and food study. https://op.europa.eu/en/publication-detail/-/publication/32d5d312-b689-11ea-bb7a-01aa75ed71a1/language-en

by the Mission Board. Note that some categories of soil degradation apply to the same land area, so that the figures do not add up.

Table 1-1: Share of EU land surface subject to each category of soil degradation

Category of soil degradation whereby soil surface fails to be considered as 'healthy'	Share of EU land surface
Direct inputs nutrient issues in agricultural systems (excluding air pollution issues)	27% – 31.5%
Low and declining carbon stocks	23%
Peatland degradation	4.8, of which 0.5% outside of agricultural areas
Soil erosion	23% cropland + 30% non-agricultural areas
Soil compaction	23-33%, of which 7% outside agricultural area
Soil pollution	2.5% (non-agricultural) – 21% (conventional arable)
Soil sealing	1 to 2.5%, with strong local concentrations
Secondary salinisation	1.5%
Desertification	(25% of Southern, Central and Eastern Europe)

Source: Interim report of the Soil Mission Board (2021)[47]

The following table provides the best available information on soil health issues at Member States level. The data available, however, identify only the aspects that could be quantified per Member State based on the information available[48]. Quantification is available only for some land uses (namely cropland or agricultural land) or for limited elements of soil degradation (e.g. only copper and mercury concentration for soil contamination; concerning salinization, only areas equipped for irrigation). The table provides therefore only an order of magnitude of the distribution of soil health issues in Member States. It is therefore possible to anticipate a provisional distributional impact among Member State, showing which Member States would be likely to have to make more of an effort than others to achieve objectives of healthy soils for each type of soil degradation for which quantification at Member State level are available.

[47] Veerman, C., Correia, T. P., Bastioli, C., Biro, B., Bouma, J., Cienciala, E., ... & Wittkowski, R. (2020). Caring for soil is caring for life: ensure 75% of soils are healthy by 2030 for healthy food, people, nature and climate: interim report of the mission board for soil health and food study. https://op.europa.eu/en/publication-detail/-/publication/32d5d312-b689-11ea-bb7a-01aa75ed71a1/language-en
[48] Details and sources of these data can be found in Annex 7

Table 1-1a: share of quantified soil health issues by Member State for each available indicator

Share of quantified soil health issues by MS for each indicator																
	Unsustainable soil erosion (water, wind, tillage, harvest)		**Low SOC compared to permanent grasslands (mineral soils only)**		**High or Very High susceptibility for topsoil compaction**	**High Copper concentrations**	**High Mercury concentrations**	**N excess**		**P excess**		**Peatland under hotspot of agriculture**		**Areas at risk of secondary salinization**		**Sealing**
Member State	% of cropland area	% of MS area	% of Cropland and Grassland area (except for land above 1000 m a.s.l.)	% of MS area	% of MS area	% of MS area	% of MS area	% of Agricultural land (CORINE)	% of MS area	% of Agricultural land (CORINE)	% of MS area	Peatland	% of MS area	Mediterranean biogeographical region	% of MS area	% of MS area
AT	68%	10%	47%	9%	4%	0%	8%	4%	1%	2%	1%	5%	0%	0%	0%	1%
BE	63%	17%	46%	15%	11%	0%	2%	69%	35%	58%	36%	0%	0%	0%	0%	6%
BG	71%	26%	84%	31%	7%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
DK	65%	45%	16%	10%	6%	0%	0%	73%	50%	31%	25%	84%	4%	0%	0%	2%
ES	72%	18%	86%	20%	7%	0%	1%	11%	3%	1%	0%	0%	0%	8%	7%	1%
EE	22%	3%	2%	0%	45%	0%	0%	0%	0%	0%	0%	72%	18%	0%	0%	0%
EL	60%	10%	83%	13%	11%	1%	0%	5%	1%	0%	0%	28%	0%	11%	10%	1%
CY	46%	14%	21%	6%	9%	0%	0%	6%	2%	-	-	0%	0%	2%	3%	2%
CZ	64%	26%	52%	22%	10%	0%	0%	0%	0%	4%	3%	0%	0%	0%	0%	2%
DE	47%	19%	43%	20%	11%	0%	1%	50%	28%	33%	20%	91%	6%	0%	0%	4%
FR	53%	16%	41%	18%	8%	3%	0%	28%	16%	16%	10%	0%	0%	5%	1%	2%
FI	17%	1%	0%	0%	6%	0%	0%	0%	0%	2%	0%	19%	7%	0%	0%	0%
HR	31%	2%	76%	7%	1%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	1%
HU	41%	24%	70%	41%	14%	0%	0%	0%	0%	0%	0%	80%	2%	0%	0%	1%
IE	42%	3%	0%	0%	8%	0%	1%	79%	46%	11%	8%	62%	12%	0%	0%	0%
IT	80%	23%	68%	19%	8%	14%	1%	23%	8%	3%	2%	1%	0%	7%	4%	3%
LT	26%	9%	29%	11%	8%	0%	0%	0%	0%	0%	0%	98%	9%	0%	0%	0%
LU	87%	12%	2%	0%	7%	0%	0%	86%	31%	1%	1%	0%	0%	0%	0%	4%
LV	25%	4%	10%	2%	13%	0%	0%	0%	0%	0%	0%	62%	6%	0%	0%	0%
MT	97%	0%	-	-	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	18%
NL	63%	16%	19%	10%	7%	0%	0%	87%	63%	90%	69%	97%	8%	0%	0%	7%
RO	59%	22%	71%	31%	8%	1%	0%	0%	0%	0%	0%	50%	2%	0%	0%	0%
PL	36%	17%	58%	29%	8%	0%	0%	15%	8%	6%	3%	87%	4%	0%	0%	1%
PT	60%	9%	29%	3%	4%	0%	0%	9%	2%	0%	0%	0%	0%	3%	3%	2%
SE	37%	3%	7%	0%	0%	0%	1%	6%	0%	5%	0%	6%	1%	0%	0%	0%
SI	64%	4%	41%	3%	8%	0%	19%	18%	4%	0%	0%	0%	0%	0%	0%	1%
SK	62%	22%	68%	23%	5%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	1%

Table 1-1b: sources used for the table 1.1a, thresholds used and specific limitations of the land uses where it was possible to quantify the area

Problem area/ indicator	% degraded areas	land uses	Threshold description (units)	Threshold reference source	links
Soil Erosion (Water, wind, tillage, crop)	54%	Cropland	Soil erosion rates above 2 ton ha^{-1} y^{-1}	Panagos et al. (2020) Borelli et al. (2017) Borelli et al. (2022) Panagos et al. (2019)	https://doi.org/10.3390/rs12091365 https://doi.org/10.1002/ldr.2588 https://doi.org/10.1038/s41893-022-00988-4 https://doi.org/10.1016/j.scitotenv.2019.02.009
SOC	53%	Cropland and Grassland (except for land above 1000 m a.s.l.)	Mineral soils below 1000 m a.s.l. that have soil organic carbon content that is more than 60 % different from the potential maximum	De Rosa et al. (2023), upcoming publication	-
Soil compaction susceptibility	8%	all area EU	High susceptibility to compaction (class)	Houšková and Montanarella (2008)	https://esdac.jrc.ec.europa.eu/content/natural-susceptibility-soil-compaction-europe
Copper	2%	all area EU	Copper concentrations above 50 mg Kg^{-1}	Ballabio et al (2018)	https://doi.org/10.1016/j.scitotenv.2018.04.268
Mercury	1%	all area EU	Mercury concentrations above 200 µg Kg^{-1}	Ballabio et al (2021)	https://doi.org/10.1016/j.scitotenv.2020.144755
N excess	23%	Agricultural land (CORINE)	Nitrogen surplus above 50 Kg ha^{-1}	Integrated Nutrient Management Action Plan (INMAP), in press	In process in Pubsy
P excess	10%	Agricultural land (CORINE)	Phosphorous concentrations above 50 mg Kg^{-1}	Ballabio et al. (2019)	https://doi.org/10.1016/j.geoderma.2019.113912
Peatland degradation (loss organic soils)	30%	Peatlands	Peatland areas under hotspots of agriculture	UNEP (2022)	https://www.unep.org/resources/global-peatlands-assessment-2022
Salinization	7%	Mediterranean biogeographical region	Areas with at least 30% equiped for irrigation (-)	Siebert et al. (2013)	https://www.fao.org/aquastat/ru/geospatial-information/global-maps-irrigated-areas/latest-version/
Soil sealing	1%	all area EU	Areas above 50% imperviousness (excluded 100% imperviousness)	EEA Impervious Built-up (IBU) 2018	https://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness/status-maps/impervious-built-up-2018

1.3.1 Aspects of the degradation of soil health

Soil health is difficult to assess directly. However, extensive research has led to the definition of indirect indicators of the physical, chemical and biological degradation of a soil. In what follows, the most commonly used indirect indicators are used to describe the current degradation of soils in the EU, and their evolution over time.

A recent review of the literature regarding the condition of soils in Europe has been provided by the EEA in its State of the European Environment report for 2020,[49] chapter 5 "Land and soil", in addition to the more recent 2022 report on soil monitoring.[50] These reports list the following aspects regarding soil degradation: Physical aspect of soil degradation: Soil (in particular: subsoil) compaction;

- Chemical aspects of soil degradation:
  - Contamination of soils by chemical pollutants (heavy metals, Persistent Organic Pollutants – POPs, pesticides, antibiotics and other pharmaceuticals, excess nutrients, microplastics, and other substances of concern);
  - Acidification of soils;
  - Salinisation of soils;
  - Nutrient losses (nitrogen and phosphorus);
- Biological aspects of soil degradation:
  - Loss of Soil Organic Carbon;
  - Loss of soil biodiversity;
  - Desertification.

Each of these aspects related to soil degradation are now presented, with an outline of the magnitude of each in the European Union.

1.3.1.1 Soil (in particular: subsoil) compaction

Soil compaction occurs when excess mechanical pressure is exerted on soils, so that the micro-cavities naturally existing in a healthy soil, and that are the habitat of underground species and the storage and transit space for underground water and air, are closed. Two types are recognised: topsoil compaction caused by the passage of machinery and animals over the land surface, subsoil compaction due to tillage operations when machinery is driven over the surface of the subsoil. Compaction is generally irreversible for the subsoil.[51]

Soil compaction is estimated at currently affecting 23% of the agricultural subsoils,[52] yet data on the compaction rates in other ecosystems/sectors which are likely to involve the usage of heavy machinery (such as forests for tree felling, inland wetlands for drainage works, urban environments for construction) is currently not available. The stress inflicted upon soils from heavy machinery has increased due to the continuing increase in wheel load in equipment used in land management practices (approximately a 600%

[49] European Environment Agency – EEA (2019) "The European environment — state and outlook 2020 Knowledge for transition to a sustainable Europe" accessible at: https://www.eea.europa.eu/soer/2020.
[50] EEA (2022) Soil monitoring in Europe. Indicators and thresholds for soil quality assessments.
[51] JRC – ESDAC https://esdac.jrc.ec.europa.eu/themes/soil-compaction
[52] Stolte et al., (2016) Soil threats in Europe.
Available at: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/doc_pub/EUR27607.pdf

increase in average wheel load of field machinery between 1960 and 2010),[53] ultimately, causing greater stress to top- and subsoils. Compaction is particularly severe when this heavy machinery is used under wet weather conditions, when the soil is softer and thus loses more volume for a given pressure.[54]

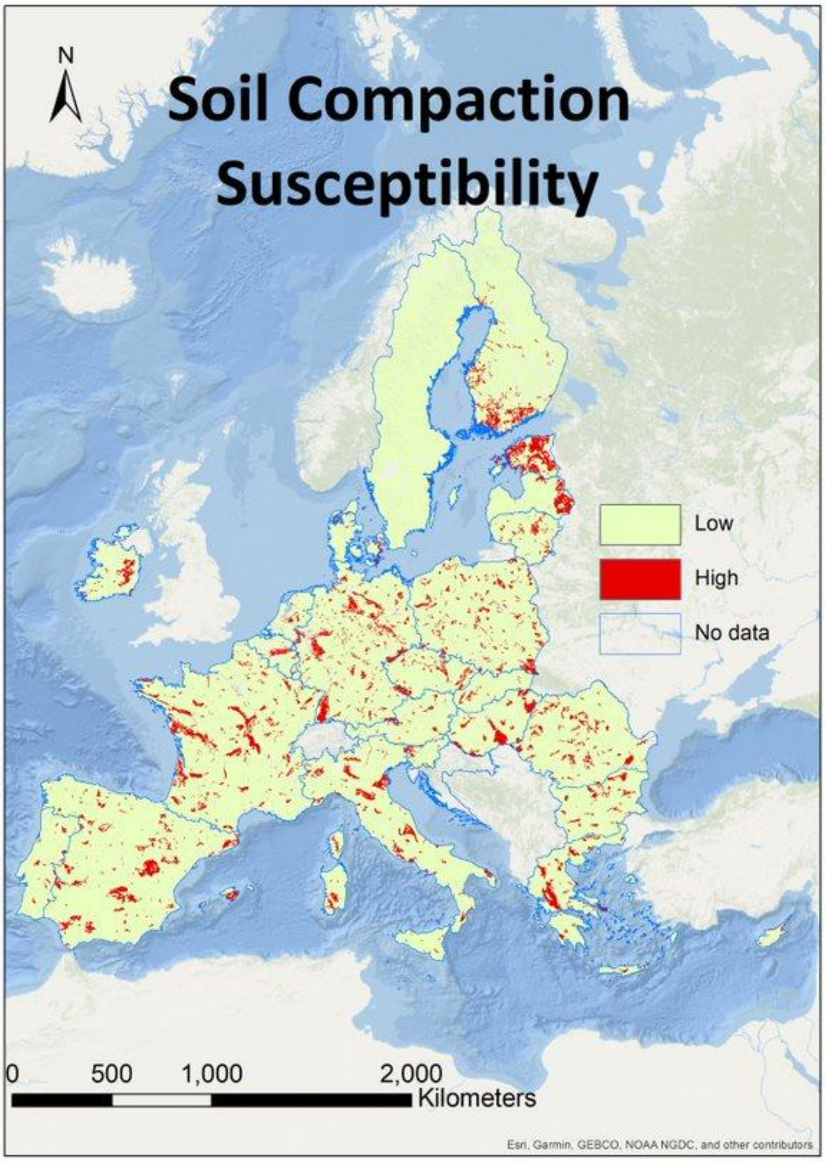
Assuming, for the sake of providing conservative figures, that compaction only covers *arable land* rather than the entirety of *utilised agriculture areas* (as heavy machinery is predominantly used in the ploughing and harvesting of crops), this proportion of 23% of compacted soils cited above translates into an estimate of 231,000 km^2 of EU-27 arable land suffering from critically high soil compaction densities in 2010, and 246,954 km^2 in 2020 (because of the evolution in arable land in the EU between these two dates). Topsoil compaction can also occur in grasslands that are harvested for hay and silage, but this surface is not integrated in the above figures on total impacted surface.

The usage of mechanical harvesting machinery in forestry leads to the formation of ruts and in soil compaction, which can be particularly severe in forests because of the richness of their soils in organic content.[55] In the absence of data regarding the share of forest soils in the EU subject to compaction, it is assumed that compaction only impacts forests which are intensively managed, which currently cover 4.4% of all EU+UK forest area,[56] i.e. 6,777,000 km^2.

Data on compaction in other ecosystems is not available currently at the EU level.

The following map produced by the JRC presents the areas with high susceptibility to compaction.

[53] Schjønning et al., (2018) Subsoil Compaction – A threat to sustainable food production and soil ecosystem services. RECARE Policy Brief. Available at: https://www.ecologic.eu/16002
[54] Bussell J, Crotty F, Stoate C. Comparison of Compaction Alleviation Methods on Soil Health and Greenhouse Gas Emissions. Land. 2021; 10(12):1397. https://doi.org/10.3390/land10121397
[55] Nazari M, Eteghadipour M, Zarebanadkouki M, Ghorbani M, Dippold MA, Bilyera N and Zamanian K (2021) Impacts of Logging-Associated Compaction on Forest Soils: A Meta-Analysis. Front. For. Glob. Change 4:780074. doi: 10.3389/ffgc.2021.780074
[56] Forest Europe (2020) State of Europe’s Forests 2020.
Available at: https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf



1.3.1.2 Soil pollution

Soil pollution refers to the presence of a chemical or substance out of place and/or present at a higher than normal concentration that has adverse effects on any non-targeted organism.[57] Soil pollution is generally classified as either point-source or diffuse pollution.

Point-source soil pollution is the one associated to contaminated soils, typically found in current or past industrial, mining, waste disposal, storage, or transport infrastructure sites, and on sites of intentional or accidental spillage. Point-source pollution is the purpose of Sub-Problem B on the legacy of contaminated sites.

Typical forms of soil pollution in these sites are related to the following contaminants:[58]

[57] Rodríguez-Eugenio, N., McLaughlin, M. and Pennock, D. 2018. Soil Pollution: a hidden reality. Rome, FAO. 142 pp. Available at: https://www.fao.org/3/I9183EN/i9183en.pdf

[58] EEA (2019) The European environment — state and outlook 2020 Knowledge for transition to a sustainable Europe

- Heavy metals;
- Persistent Organic Pollutants (POPs);
- Polycyclic Aromatic Hydrocarbons (PAH).

Furthermore, **diffuse soil pollution** presents a significant form of contamination throughout EU soils. Such contamination often spreads over large areas, and does not stem from single, easily identifiable sources, meaning that challenges persist in presenting an EU-wide picture of diffuse soil contamination.[59] These contaminants originate mainly from the use of fertilisers, the application of agrochemicals and manures- which contain contaminated residues,[60] road traffic or the dilution or diffusion of point-source pollution. Once generated, these contaminants are often further transported by air and water processes.[61] These diffuse contaminants are explored in the sections below.

Heavy metals

As regards to diffuse soil pollution, it is estimated that 137,000 km^2 of EU agricultural land has high concentrations of heavy metals (i.e., with any kinds of heavy metal concentration above the guideline value set for agricultural land by the Finnish legislation for contaminated soil),[62] representing 6.24% of the total agricultural area. Moreover, 2.56% of the agricultural soils investigated contained heavy metal in concentration which would require remediation if these were originated from industrial or transport areas, based on the same Finnish guidelines values.[63]

It is estimated that currently critical threshold concentrations for copper, cadmium, lead and zinc in agricultural soils do not exceed soil (biodiversity) threshold values. However, in the longer run, inputs of copper and zinc (the sum of uptake rate and leaching rate) currently surpass the calculated maximum levels compatible with an equilibrium with the ecological critical soil concentrations. This leads to a gradual increase in the soil concentration for copper and zinc – potentially causing negative soil biodiversity impacts in the future. Ultimately, at EU level, it is estimated that zinc, copper and lead are accumulating in soils, whilst cadmium is undergoing a net loss.[64] The higher concentration of copper has been found in vineyards and orchards in areas with humid conditions and are explained by the intense use of fungicides.[65]

Regarding mercury, in an elaborated assessment, Ballabio et al. (2021) found that mercury hotspots in the EU are close to mine areas, chlor-alkali industries and coal-fired power plants.[66] Significant differences occur within and between MSs – largely

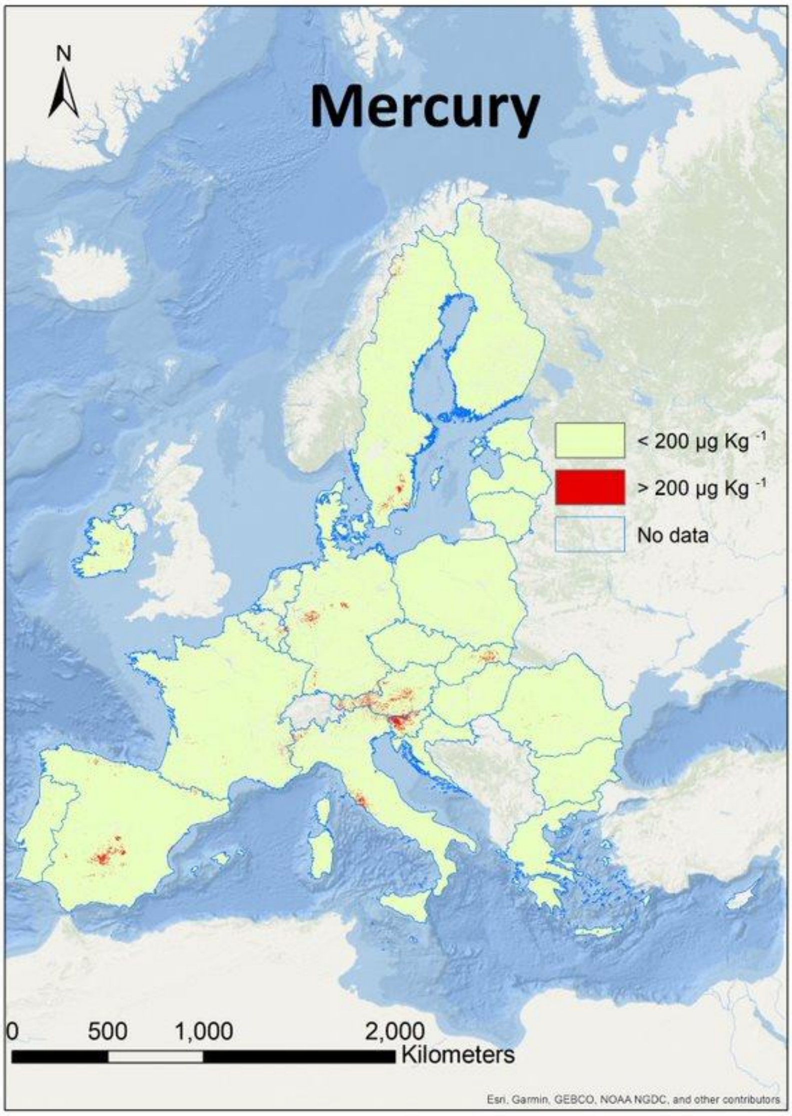
[59] Payá Pérez and Eugenio (2018) Status of local soil contamination in Europe. JRC Technical Report.
[60] IUNG (2019) The impact of soil degradation on human health. Institute of Soil Science and Plant Cultivation (IUNG). Available at: https://www.deltares.nl/app/uploads/2019/02/Deliverable1.7-Report-5-FINAL-DEF.pdf
[61] Rodríguez-Eugenio, N., McLaughlin, M. and Pennock, D. 2018. Soil Pollution: a hidden reality. Rome, FAO. 142 pp, available at: https://www.fao.org/3/I9183EN/i9183en.pdf
[62] Ministry of the Environment, Finland "Government Decree on the Assessment of Soil Contamination and Remediation Needs" (2007), (214/2007, March 1, 2007)
[63] Tóth et al., (2016) Heavy metals in agricultural soils of the European Union with implications for food safety. https://doi.org/10.1016/j.envint.2015.12.017
[64] De Vries et al., (2022) Impacts of nutrients and heavy metals in European agriculture. Current and critical inputs in relation to air, soil and water quality, ETC-DI.
[65] Cristiano Ballabio, Panos Panagos, Emanuele Lugato, Jen-How Huang, Alberto Orgiazzi, Arwyn Jones, Oihane Fernández-Ugalde, Pasquale Borrelli, Luca Montanarella, "Copper distribution in European topsoils: An assessment based on LUCAS soil survey", Science of The Total Environment, Volume 636, 2018, Pages 282-298, https://doi.org/10.1016/j.scitotenv.2018.04.268
[66] Cristiano Ballabio, Martin Jiskra, Stefan Osterwalder, Pasquale Borrelli, Luca Montanarella, Panos Panagos, "A spatial assessment of mercury content in the European Union topsoil", Science of The Total Environment, Volume 769, 2021, https://doi.org/10.1016/j.scitotenv.2020.144755 .

dependent on agricultural management practices, soil type, and climatic conditions,[67] in addition to the source in which pollutants are emitted (e.g. point-source pollution vs pollutant emitted into the atmosphere).[68]

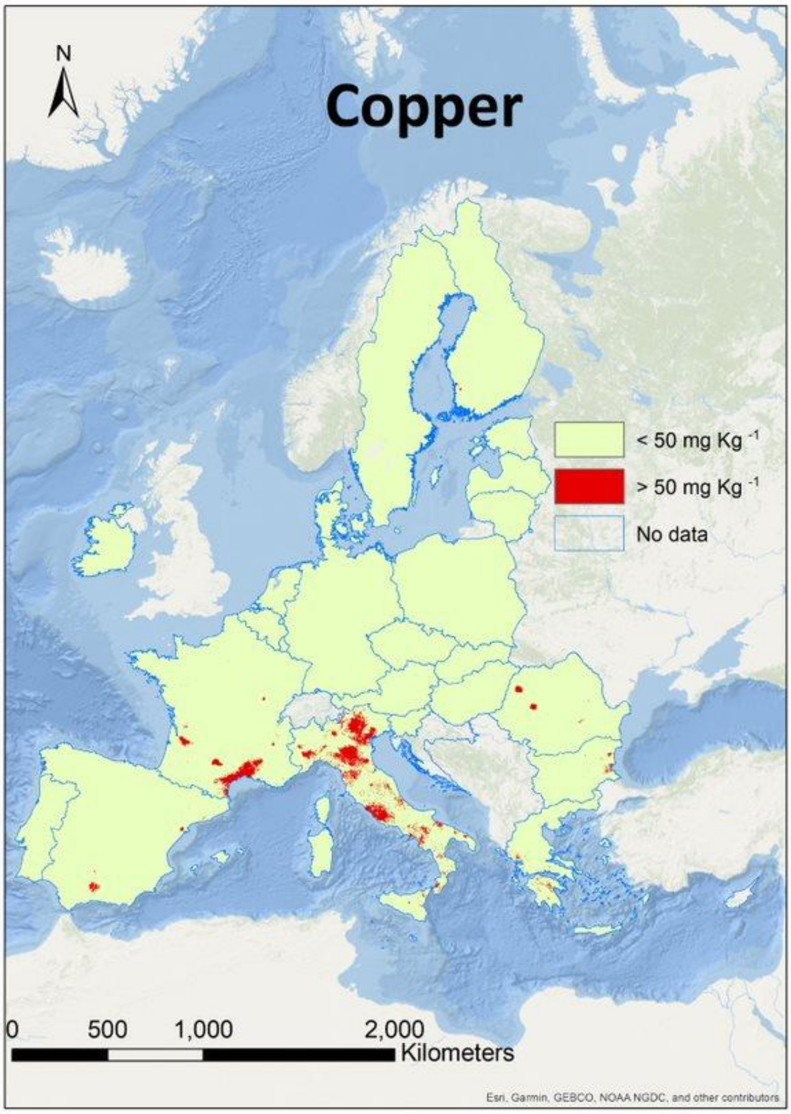
When looking beyond solely agricultural soils, data are relatively limited. A study by Panagos et al. in 2021 estimated that the average concentration levels of mercury in topsoil was 103 g/ha, equating to 44,800 tonnes across the EU. Importantly, in relation to transboundary impacts, the same study estimated that approximately 6 tonnes per year are transferred with sediments by water erosion within river basins (EU-27+UK) and consequently transported downstream.[69] Toth et al. (2016)[70] evidenced that topsoil heavy metal concentrations (arsenic, cadmium, chromium, copper, mercury, lead, zinc, antimony, cobalt and nickel) showed varied distribution throughout the EU, with numerous instances of high concentration pollution – likely due to point-source pollution.

The following map produced by the JRC presents the areas with high concentration of mercury in soil.

[67] De Vries et al., (2022) Impacts of nutrients and heavy metals in European agriculture. Current and critical inputs in relation to air, soil and water quality, ETC-DI.
[68] De Vries et al., (2022) Impacts of nutrients and heavy metals in European agriculture. Current and critical inputs in relation to air, soil and water quality, ETC-DI.
[69] Panagos et al., (2021) Mercury in European topsoils: Anthropogenic sources, stocks and fluxes.
[70] Tóth et al., (2016) Maps of heavy metals in the soils of the European Union and proposed priority areas for detailed assessment.



The following map produced by the JRC presents the areas with high concentration of copper in soil.



Pesticides and Persistent Organic Pollutants (POPs)
Diffuse pollution by agro-chemicals[71] is a major threat to soil health. Such pollutants, as well as their toxic degradation products, are particularly susceptible to transport by water and air leading to off-site contamination, which may ultimately impair ecosystem functioning.[72] Pesticides, for example, damage beneficial soil-dwelling invertebrates, as shown by a study evidencing that 71% of pesticide application led to negative impacts on soil organisms,[73] which ultimately underpin soil health. In addition, several pesticide active substances or their metabolites are persistent, bio-accumulative, or toxic to humans and non-target-species.[74]

[71] For the purpose of this study- this includes pesticides, insecticides, herbicides, fungicides, nematicides, synthetic fertilizers, hormones, chemical growth agents, and concentrated stores of raw animal manure.
[72] Silva et al., (2019) Pesticide residues in European agricultural soils – A hidden reality unfolded.
[73] Gunstone et al., (2021) Pesticides and soil invertebrates: A hazard assessment.
[74] Vera Silva, Xiaomei Yang, Luuk Fleskens, Coen J. Ritsema, Violette Geissen, "Environmental and human health at risk – Scenarios to achieve the Farm to Fork 50% pesticide reduction goals", Environment International, Volume 165, 2022,107296, https://doi.org/10.1016/j.envint.2022.107296

In relation to pesticides, only limited data is available on the actual application of pesticides in the EU. The recent JRC study on pesticides in soils from LUCAS 2018 samples found that intensive-medium use of pesticides was more prevalent in land covers such as cereals, non-permanent industrial crops, and other permanent crops (40%, 9%, and 7% respectively, of locations had intensive-medium use of pesticides).[75] When observing proxies for pesticide application, such as pesticide sale data – it is apparent that between the period 2011 to 2019, sales of pesticides have fluctuated increasing from around 215,000 tonnes in 2011 to over 345,000 tonnes in 2017 (although 2011-2015 data is a significant underestimate due to the lack of data from numerous MSs). The EU Ecosystem Assessment concluded in 2020 that pesticide sales trend data was stable.[76]

Table 1-2: Annual pesticide sales per UAA in EU-27, 2011-2020

Year	Pesticide sales (tonnes)	Utilised Agricultural Area (km^2)	Pesticide sales per UAA (t/km^2)
2011	**215,674**	**1,621,934**	**0.13**
2012	**233,988**	**1,609,158**	**0.15**
2013	**225,156**	**1,610,098**	**0,14**
2014	**239,800**	**1,612,937**	**0,15**
2015	**212,888**	**1,617,946**	**0,13**
2016	**336,270**	**1,614,077**	**0,2**
2017	**347,466**	**1,614,559**	**0,22**
2018	**333,612**	**1,619,491**	**0,20**
2019	**321,292**	**1,629,260**	**0,20**
2020	**345,508**	**1,622,421**	**0,21**

Source: Pesticide sales data from EUROSTAT (2022), Pesticide Sales. online data code: aei_fm_salpest09. Utilised agricultural area data from EUROSTAT (2022) Utilised agricultural area by categories. Available at: https://ec.europa.eu/eurostat/databrowser/view/tag00025/default/table?lang=
Note: Data between 2011-2015 likely to be significantly underestimated as only 10-12 MSs reported their pesticide sales data in this period.

Persistent Organic Pollutants (POPs) emissions traditionally originated from industrial, combustion, and agricultural sources, and now also stem from commercial products, which are then disposed of by consumers. For example, some plastics contain POPs as additives, such as hexabromocyclododecane and polybrominated diphenyl ether (used as flame retardants) which are used in products for thermal insulation and upholstery which are often placed in landfill sites. As such, emissions from the waste sector to soil (e.g. through sludge application) is therefore also relevant for the newer POPs, as a result of their commercial uses and waste disposal fate pathways.[77]

The latest EU study from year 2011 contains almost no data on the POPs contamination of soils, with data provided on four pollutants (PCDD/Fs, B(a)P, PCB-153 and g-HCH) being from 2008 and being described as having a highly questionable reliability.[78] Data officially compiled by the Parties under the Stockholm Convention on POPs for 2021 is slightly more informative, as more data was collected in the 10 years elapsed between the

[75] Orgiazzi et al., (2022) LUCAS Soil Biodiversity and LUCAS Soil Pesticides, new tools for research and policy development
[76] Maes et al (2020) Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment.
[77] Regional Monitoring Report for Western Europe and other States Group (WEOG) 2021 http://chm.pops.int/Implementation/GlobalMonitoringPlan/MonitoringReports/tabid/525/Default.aspx
[78] European Commission DG ENV (2011) Technical support on POP regulation https://ec.europa.eu/environment/chemicals/international_conventions/pdf/syntesis_report2.pdf

reports, but information gaps still remain and some information is missing. Notably, the regional report for the Western Europe and Others Group (WEOG)[79] included Table 1-3 on the changes over time in POP concentrations in air and human tissues, which can be used as rough proxies for soil contamination. Moreover, an analysis of long-term POPs pollution trends presented during a TF HTAP Workshop on POPs Trends and Source Attribution in April 2021 notes a lack of decrease in B(a)P air pollution in the past two decades in the EMEP region as well as some high concentrations of PCDD/Fs in the air in Europe.[80]

Table 1-3: Summary of changes over time in POP concentrations measured in air and human tissues for the WEOG region.

Chemical	Air	Human Tissues**
aldrin		
chlordane		
chlordecone	No data	
Dicofol	No data	Not included
DDT		
dieldrin	No change at some sites	
endosulfan		
endrin	*	
HBB	No data	
HCBD	*	
HBCD	Few detections; decline at one site	
HCB	Slight increase at some polar sites	
α HCH		Not investigated
β HCH		Decrease in milk but not in blood
γ HCH		Not investigated
Heptachlor	Declining at some sites	
mirex		
PBDEs		
PBDE-209 (Deca)	Increasing at some sites	
Pentachlorophenol	* reported as PCA	*only German data
PCNs	No data	
Σ PCBs	Increase in the Alps	
PCDD/Fs		
PFOS	*	
PFOA	*	
PFHxS		
PeCB	Decrease in the Alps	
SCCPs	*	
toxaphene		*

	Generally decreasing trends
	Increasing trends
	No change or cannot establish trend
	Insufficient trend data

* warning to indicate limited data. ** these should be taken as general indicators since information varies between countries and subregions within WEOG.

Source: 3rd regional monitoring report - Western Europe and Others Group (WEOG) (2021). Global Monitoring Plan for POP under the Stockholm Convention article 16 on effectiveness evaluation

[79] Regional Monitoring Report for Western Europe and other States Group (WEOG) 2021 http://chm.pops.int/Implementation/GlobalMonitoringPlan/MonitoringReports/tabid/525/Default.aspx

[80] https://msceast.org/index.php/cooperation/task-forces/tfhtap

A lack of data is also apparent in relation to emerging contaminants such as Perfluoroalkyl chemicals (PFASs). Per- and polyfluoroalkyl substances (PFASs) are a large class of thousands of synthetic chemicals that are widely used throughout society and found in the environment.

They all contain carbon-fluorine bonds, which are one of the strongest chemical bonds in organic chemistry. This means that they resist degradation when used and also in the environment. Most PFASs are also easily transported in the environment covering long distances away from the source of their release. Cleaning up polluted sites is technically difficult and costly.[81]

PFASs, due to their widespread usage, toxicity and persistence in the environment, have been noted as being widespread throughout the soils, water and waste in the EU.[82]

Veterinary products, other pharmaceuticals and personal care products
In 2020, 5,507.4 tonnes of active substance of antimicrobial Veterinary Medicinal Products for use in food-producing animals was sold in Europe (EU-27, UK, Iceland, Norway, and Switzerland). In the past decade (2011-2020), an overall decrease of 43.2% was reported in sales by the 25 countries which provided annual data to the European Medicines Agency.[83] Self-reported use of medicines has remained somewhat stable in the EU across the past few years, from 33.6% to 32.5% of the population consuming non-prescribed medicines in 2015, and from 48.1% to 47.9% for prescribed medicines.[84] Veterinary products accumulate in the soil via manure application,[85] whereas pharmaceuticals and personal care products consumed by humans can accumulate in soils via sewage sludge application.[86] However, no data exists on the scale of contamination from pharmaceuticals (including veterinary) and personal care products at EU level.

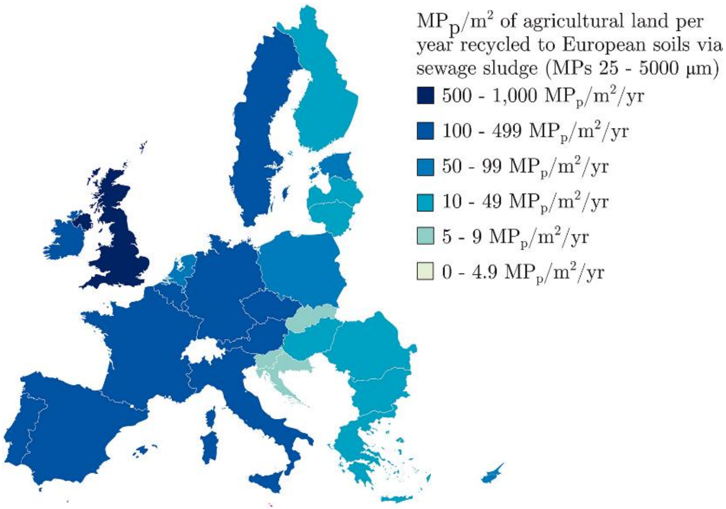
Plastics and microplastics
Eurostat data shows that plastic waste generation has been steadily increasing in the EU-27 in the past years, from 9.5 million tonnes in 2004 to 17.2 million tonnes in 2018,[87] also highlighting an increase in the consumption of plastic, with potential consequences on EU soils depending on waste disposal methods and use of plastic in agriculture or civil engineering (geotextiles).

Furthermore, attention to microplastics (globally and in the EU) has been amplified due to the prevalence of microbeads in cosmetics and ultimately in the environment, as well as the presence of microplastics in foodstuffs.[88] However, data on the extent of microplastic (MP) pollution in EU soils is lacking. One study[89] has estimated that the

[81] Source: ECHA, page on PFAS: https://echa.europa.eu/hot-topics/perfluoroalkyl-chemicals-pfas
[82] Council of the European Union (2019) Towards a Sustainable Chemicals Policy Strategy of the Union
[83] European Medicines Agency (2021) Sales of veterinary antimicrobial agents in 31 European countries in 2019 and 2020. Available at: https://www.ema.europa.eu/en/documents/report/sales-veterinary-antimicrobial-agents-31-european-countries-2019-2020-trends-2010-2020-eleventh_en.pdf
[84] Eurostat (2022) Self-reported use of non-prescribed medicines by sex, age and educational attainment level; Eurostat (2022) Self-reported use of prescribed medicines by sex, age and educational attainment level;
[85] Gros et al., (2018) Veterinary pharmaceuticals and antibiotics in manure and slurry and their fate in amended agricultural soils: Findings from an experimental field site
[86] Gworek et al., (2021) Pharmaceuticals in the Soil and Plant Environment: a Review
[87] Eurostat (2022) Generation of waste by waste category, hazardousness and NACE Rev. 2 activity
[88] EC (2019) Environmental and Health Risks of Microplastic Pollution.
[89] Lofty et al., (2022) Microplastics removal from a primary settler tank in a wastewater treatment plant and estimations of contamination onto European agricultural land via sewage sludge recycling

application of MP to EU soils via sewage sludge – which is one route for MP pollution of soils, amongst others[90] – amounts to between 31,000 and 42,000 tonnes annually. The pressure from one source, per EU MS (and for the UK) is shown in the Figure 1-3**Error! Reference source not found.**.[91] Furthermore, MP pollution from tyre wear was found to result in an approximate 57,300- 65,400 tonnes per annum in soils near roads in Germany alone.[92]

Figure 1-3: The relative MP pressure on European agricultural soils, per nation, caused by recycling MP-laden sewage sludge, expressed as MPp/m²/yr.



Source: Lofty et al., (2022) Microplastics removal from a primary settler tank in a wastewater treatment plant and estimations of contamination onto European agricultural land via sewage sludge recycling

In agriculture, both single-use and long-term use plastics are used extensively in a direct way. Single-use plastic is mostly used as plastic mulching (at an estimated rate of 100,000 tonnes annually in the EU),[93] but also for packaging to conserve agricultural products and as a coater for controlled-release fertilizers. Both plastic mulching and plastic in fertilizer products can cause accumulation in the soils, whereas packaging is disposed off-site (e.g., at the distribution or post-consumption stage). Plastic used on a longer-term is used to build greenhouses, tunnels, crop protection nets and irrigation systems. This type of plastic undergoes a slow degradation in the environment, mainly due to weathering. Some secondary sources of plastic debris in agriculture also exist, notably from compost, sewage sludge and irrigation water. Ultimately, both direct and indirect plastic used in agriculture can end up in the soil, in water bodies, and in the air.[94]

Microplastic can cause diseases (cancers, respiratory diseases, effects on endocrine systems, etc.),[95] via (inter alia) transmission into food from soils, with an estimated

[90] Microplastic pollution is also caused by abrasions (road traffic, packaging, fibers of textiles during washing), waste disposal (landfills), and application to soils via compost

[91] Lofty et al., (2022) Microplastics removal from a primary settler tank in a wastewater treatment plant and estimations of contamination onto European agricultural land via sewage sludge recycling.

[92] Baensch-Baltruschat et al., (2021) Tyre and road wear particles-a calculation of generation, transport and release to water and soil with special regard to German roads.

[93] Commission Staff Working Document (SWD). Impact Assessment accompanying the Proposal for a Regulation laying down rules on the making available on the market of CE marked fertilising products; SWD/2016/064 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52016SC0064

[94] EIP AGRI (2020) Reducing the plastic footprint of agriculture. Available at: https://ec.europa.eu/eip/agriculture/sites/default/files/eip-agri_fg41_plastic_footprint_starting_paper_2020_en.pdf

[95] Lim (2021) Microplastics are everywhere- but are they harmful? Available at: https://www.nature.com/articles/d41586-021-01143-3

39,000–52,000 particles being ingested per person per year.[96] Microplastics also influence the terrestrial environment by: (i) altering soil physicochemical properties (e.g., they tend to tend to increase soil bulk density, decrease porosity, water holding capacity, hydraulic conductivity and water stable aggregates to various extent depending on the type of debris and the type of soil); (ii) affecting micro-organisms; (iii) negative effects on plant growth, and especially root growth, with potential effects on yield and on the quality of the food produced; (iv) ingestion by macro-organisms;[97] and (v) through leaching toxic chemicals into soils through degradation – which can also serve as a media for harmful pathogens.[98]

1.3.1.3 Acidification of soils

Soil acidification is a process during which the soil pH decreases over time. Exposure of ecosystems to acidification due to atmospheric deposition in the EU-28 has decreased since the 1980s, with critical loads of sulphur dropping from a surface of 43% in 1980 to 7% in 2010. In 2010, most acidification was observed in the Netherlands, Belgium, western Germany, Poland and Czech Republic. The EEA estimated that by 2020, acidification would further decrease and remain concentrated in the same areas of Europe.[99]

In parallel, when ammonium-NH_4^+, in fertilizers or through de deposition of fossil fuel combustion gasses, undergoes nitrification (conversion of ammonium to nitrate in soils by bacteria), hydrogen (H+) is released, which can increase acidity. This can impact, inter alia, soil biodiversity, organic matter content and N-fixation capacity.[100]

1.3.1.4 Salinisation of soils

Soil salinisation, the accumulation of soluble salts in soil through natural processes and human interventions, can significantly impact the physicochemical and ecological functions of soil.[101]

A common driver of secondary salinity is irrigation, either as a result of rising groundwater tables (from excessive irrigation) or the use of poor-quality water. In the EU, it is estimated that approximately 4 million hectares of all soils have moderate to high levels of salinisation-induced degradation. Coastal areas can be exposed to increased salinisation processes, due to intensified abstractions of groundwater or of surface water (to create polders)[102] and resultant saltwater intrusions.[103]

The following map produced by the JRC presents the areas with saline areas in areas equipped with irrigation.

[96] Assumptions based on an American diet.- from, Cox et al., (2019) Human consumption of microplastics.
[97] https://ec.europa.eu/eip/agriculture/sites/default/files/eip-agri_fg41_plastic_footprint_starting_paper_2020_en.pdf
[98] Lofty et al., (2022) Microplastics removal from a primary settler tank in a wastewater treatment plant and estimations of contamination onto European agricultural land via sewage sludge recycling.
[99] EEA (2019) Exposure of Europe's ecosystems to acidification, eutrophication and ozone.
Available at: https://www.eea.europa.eu/data-and-maps/indicators/exposure-of-ecosystems-to-acidification-14/assessment-2
[100] Velthof et al., (2011) Chapter 21- Nitrogen as a threat to European soil quality. In: Sutton et al., The European Nitrogen Assessment.
[101] Daliakopoulos et al., (2016) The threat of soil salinity: A European scale review.
[102] The salinisation levels of coastal Flanders have thus been investigated by the TOPSOIL Interreg project: https://northsearegion.eu/topsoil/news/topsoil-maps-salinization-in-coastal-and-polder-area-in-flanders/
[103] Daliakopoulos et al., (2016) The threat of soil salinity: A European scale review.

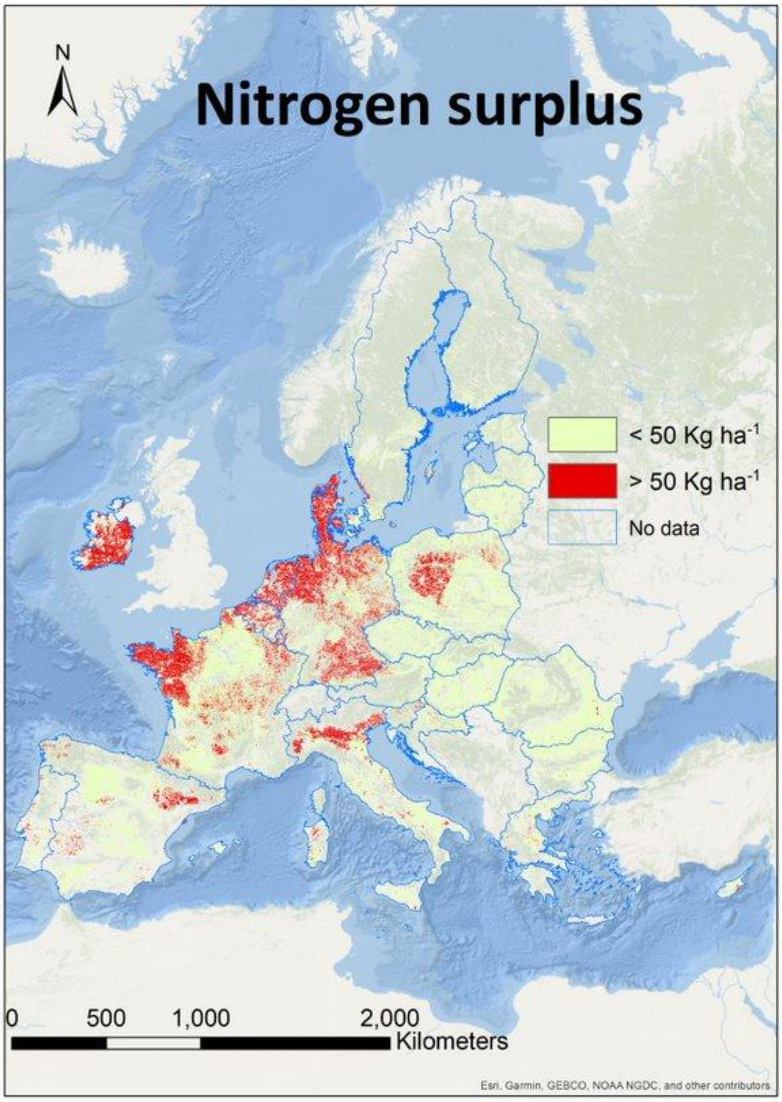
1.3.1.5 Nutrient losses

The application of fertiliser and manure which exceeds the uptake capabilities of plants and crops can cause significant negative impacts on waterways and biodiversity. In addition, mycorrhizal fungi, which underpin a plethora of soil functions and services (due to their symbiotic linkage they create between plants and soil), are commonly negatively impacted by the overapplication of nutrients.[104]

It is estimated that 67% of Europe's ecosystem area is exposed to excessive **nitrogen (N)** levels (78% of Natura 2000 areas, 65-75% of agricultural soils), mainly due to fertiliser use in agriculture. In the EU, between 2000-2015 the nitrogen surplus level and overall efficiency of nitrogen usage has improved, yet the EU remains exposed to a high surplus of nitrogen.[105]

[104] Origiazzi et al., (2016) Global Soil Biodiversity Atlas. European Commission.
[105] EEA (2019) The European environment— state and outlook 2020.

The following map produced by the JRC presents the areas with high concentration of nitrogen in soil.

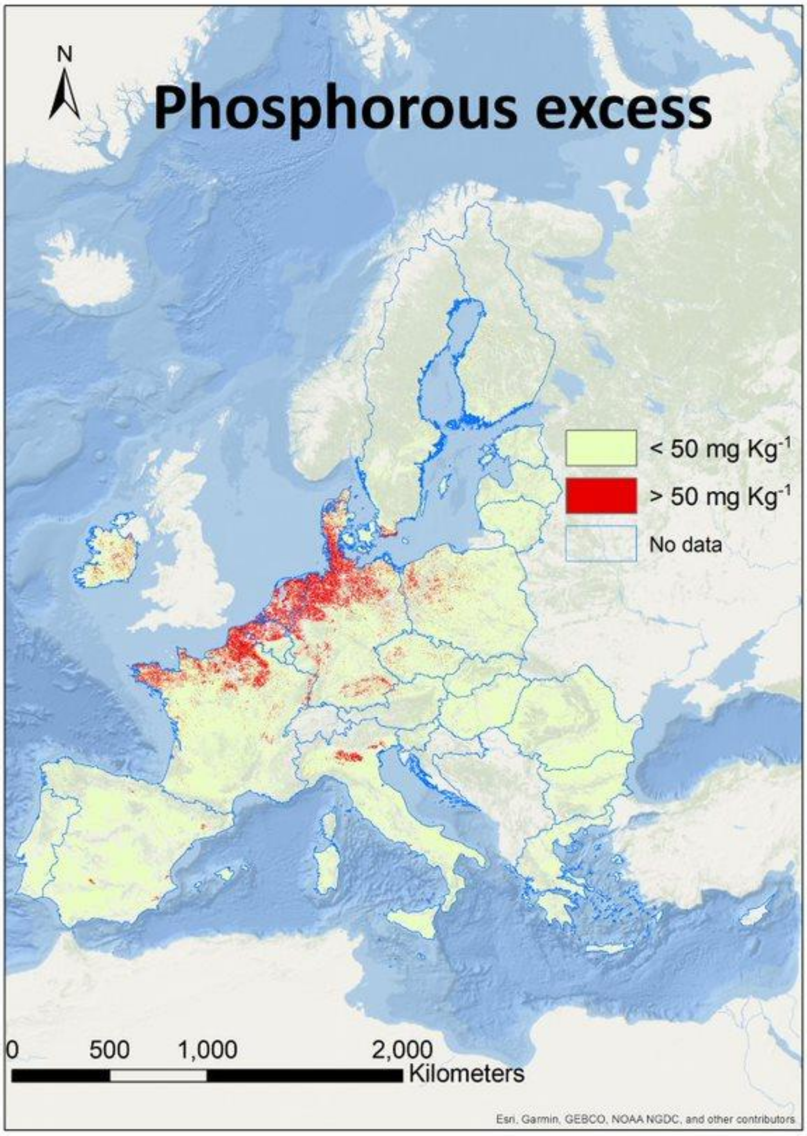


Similarly, **phosphorus (P)** has accumulated in EU agricultural soils since the introduction of mineral P-containing fertilisers in addition to manure.[106] The accumulation of P in the soil increases the potential for P in a soluble form, more prone to losses as leaching and runoff, particularly in soils with high P surpluses in topsoils, causing environmental pollution like eutrophication of freshwaters and algae bloom, leading to hypoxia and, hence, degradation of water quality, destruction of fisheries and high public health risk. P imbalances are the third biggest threat to planetary boundaries, calling for an urgent reduction.[107]

The following map produced by the JRC presents the areas with high concentration of nitrogen in soil.

[106] Antikainen, R., Haapanen, R., Lemola, R. et al. Nitrogen and Phosphorus Flows in the Finnish Agricultural and Forest Sectors, 1910–2000. Water Air Soil Pollut 194, 163–177 (2008). https://doi.org/10.1007/s11270-008-9705-0

[107] Panos Panagos, Julia Köningner, Cristiano Ballabio, Leonidas Liakos, Anna Muntwyler, Pasquale Borrelli, Emanuele Lugato, "Improving the phosphorus budget of European agricultural soils", Science of The Total Environment, Volume 853, 2022, 158706, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2022.158706



Between 2000-2015, the agricultural nitrogen surplus was estimated as decreasing by 18%.[108] Similarly, in the EU, phosphate (P_2O_5) consumption has declined from 5.7 million tonnes in 1990 to 2.8 million tonnes in 2020, corresponding to 2.4 and 1.2 million tonnes of phosphorous (P) respectively.[109] Despite this decrease in usage, the overall P surplus in the EU+UK remains and is estimated at 0.8 kg P/ha/yr with high variability between countries with some regional variations, to be compared to the yearly mean P input of 16 ± 2 kg P/ha/yr at 90 % confidence level.[110]

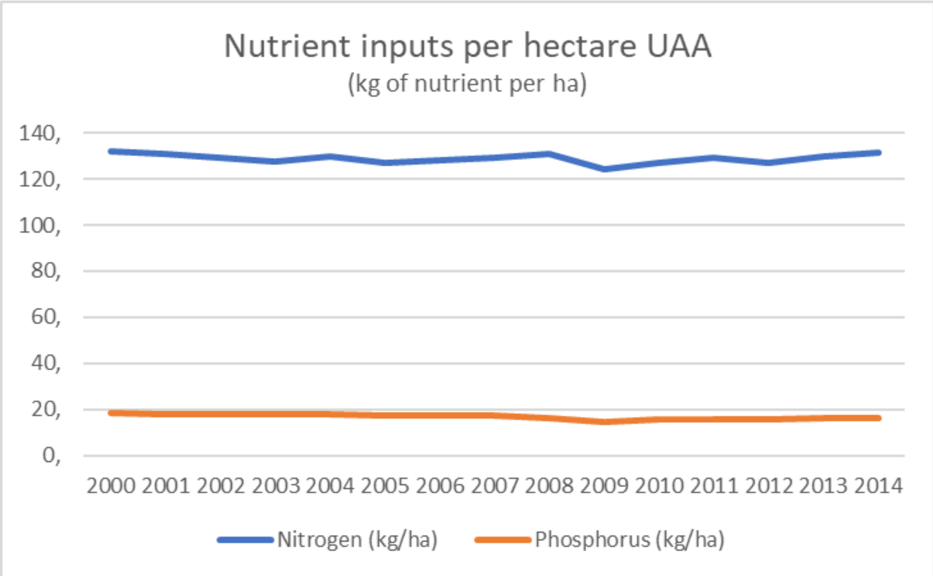
Consequently, it is estimated that a 40% decrease in nitrogen inputs, and 10% decrease in phosphorus inputs, in arable lands would be required to prevent critical exceedance levels.[111] Figure 1-4 below highlights the annual consumption of both nitrogen and

[108] EEA (2018) Agriculture: nitrogen balance. SEBI 019
[109] Fertilizers Europe, Facts & Figures (accessed 24-Nov-2022): https://www.fertilizerseurope.com/fertilizers-in-europe/facts-figures/
[110] Panos Panagos, Julia Köningner, Cristiano Ballabio, Leonidas Liakos, Anna Muntwyler, Pasquale Borrelli, Emanuele Lugato, "Improving the phosphorus budget of European agricultural soils", Science of The Total Environment, Volume 853, 2022, 158706, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2022.158706
[111] De Vries et al., (2022) Impacts of nutrients and heavy metals in European agriculture. Current and critical inputs in relation to air, soil and water quality, ETC-DI; EC (2021), EU agricultural outlook for markets, income and environment, 2021-2031.

phosphorus in EU-27 per ha of utilised agricultural area (UAA), from all sources of nutrients (mineral and organic, i.e. essentially manure).

As can be seen from these figures, the use of nitrogen per hectare has hardly evolved over the years 2000 to 2014, while that of phosphorus declined at a very low rate.

Figure 1-4: Total annual consumption of N and P nutrients in the EU-27, per ha of UAA



Source: EUROSTAT (2022) Gross nutrient balance online data code: AEI_PR_GNB, available at: https://ec.europa.eu/eurostat/databrowser/view/AEI_PR_GNB__custom_3948751/default/table?lang=en
Note: No data available from 2015 onwards.

1.3.1.6 Loss of Soil Organic Carbon (SOC)

Soil organic matter (SOM) has close relationship to almost all soil functions: it is energy and carbon source for soil organisms and affects the temperature and hydrology of soil; it affects soil aggregation (thus erodibility of the soil), pore volume, the total reactive soil micro-surface, and thus biochemical processes including mineralisation rate, cation exchange, but also nitrogen (N) losses and greenhouse gas emissions; hence, SOC also affects storage and release of nutrients and heavy metals, and it contributes to soil acidity (forest floors, Podsols) or its buffering. With regard to greenhouse gases, soils can, under certain conditions, sequester carbon and thus contribute to climate change mitigation, removing CO_2 from the atmosphere.

SOM (as much as SOC) is today recognised as critical to preserve food security, and SOM decline leads to soil degradation because its loss is often followed by decreases in soil fertility and stability. SOC can be considered a “universal keystone indicator”.

Soil organic matter (SOM) is the sum of all dead organic components of different decomposition stages in a soil that are made from basic elements including carbon, nitrogen, oxygen, hydrogen and an array of cations and ions attached to it. Since SOM is difficult to measure directly, it is common practice to measure and report soil organic carbon (SOC). Historically, for the conversion of SOC to SOM a factor of 1.724 is used, based on the assumption that organic matter is 58% carbon.[112]

The soils of the EU+UK, without Cyprus and Croatia, are estimated to store approximately 38 billion tonnes of organic carbon in the first 20 cm of soil.[113] This is an important stock considering MS annually emit around 4.4 billion tons of CO_2eq. Therefore, SOC represents an important part of the carbon cycle and protecting and enhancing SOC stocks is important for climate change mitigation. Soils can be a net sink or source of carbon depending on their management. The depletion of SOC leads to a decrease in the carbon sequestration function of soils as it decreases GHG buffering and increases emissions.

SOC concentration is considered unhealthy when it falls below the value where essential ecosystem services such as carbon stocking and water retention are impaired.[114] However, defining universal thresholds for SOC concentration is challenging due to differences in soil types[115] and climatic conditions. Importantly, a clear distinction between mineral and organic soils is required when assessing SOC. In mineral soils, which cover 92.1% of the EU land surface,[116] low SOC content levels are typically recorded, whereas organic soils (which cover only 7.9% of the EU land surface) store more than 30% of global SOC.[117]

Based on a threshold for SOC/clay ratio, it is estimated that 37.1% of EU-25 (where data is available) agricultural soils are SOC degraded.[118]

The evolution of SOC over time is slow, but on a negative trend. Based on the results of the LUCAS campaigns of 2009/2012 on the one hand, and of 2015 on the other hand, a study by JRC identified that the total change in carbon stocks in the EU in grassland was about 0.04 % and in arable land about 0.06 %, with variations between Member States.[119]

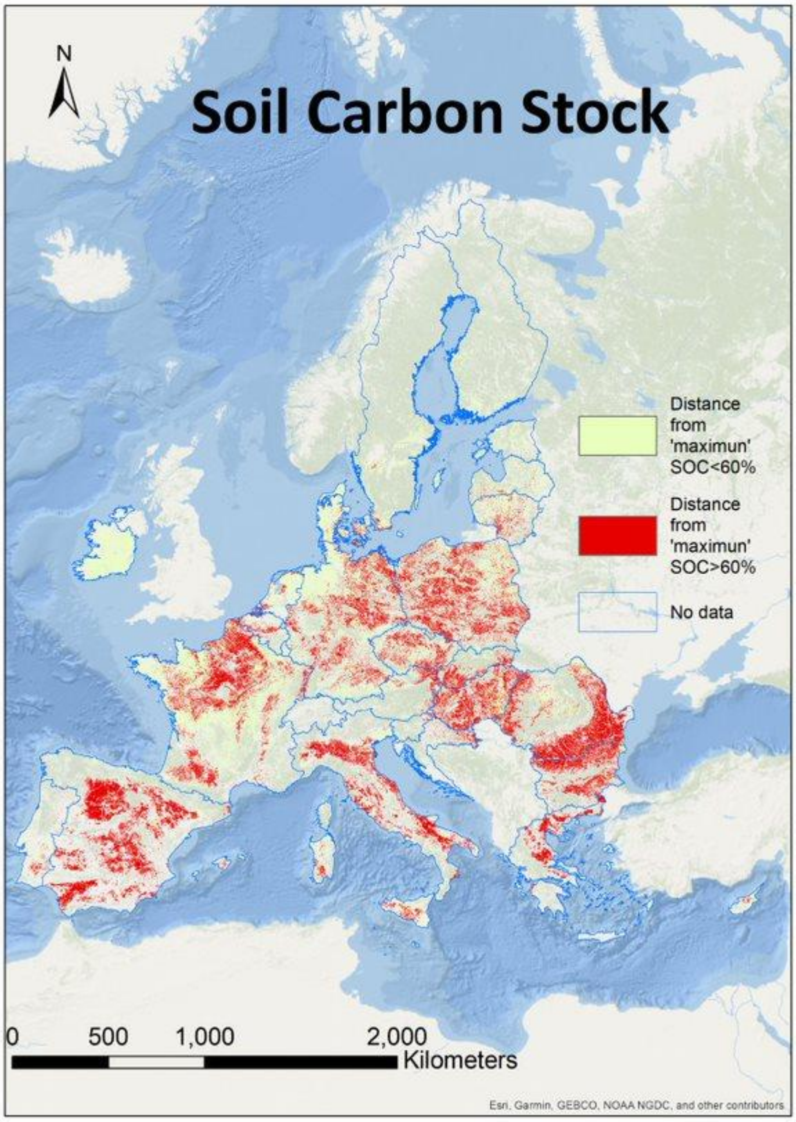
Soil carbon is currently being reported in the EU's greenhouse gas emissions inventory set up for the sake of climate reporting. The main conclusion of this monitoring is that, overall, EU soils are losing carbon. In 2019, Member States reported net emissions of 108 million tonnes CO_2eq from organic soil and net removals of 44 million tonnes CO_2eq from mineral soil,[120] resulting in net emissions from soil equal to 64 million tonnes CO_2eq.

[112] EEA (2022) Soil monitoring in Europe- Indicators and thresholds for soil quality assessments.
[113] Yusuf Yigini, Panos Panagos, "Assessment of soil organic carbon stocks under future climate and land cover changes in Europe", Science of The Total Environment, Volumes 557–558, 2016, Pages 838-850, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2016.03.085
[114] Merante (2014) Report on critical low soil organic matter contents, which jeopardise good functioning of farming systems. SmartSoil project deliverable 2.4.
[115] Based on currently available information, the EEA estimated thresholds for optimal SOC on cropland of 1,5% (1-2) for sand, 1.9 % (1,4-2,4) for silt and 1,6 % (1-2,8) for loam and clay. As outlined in the soil condition section, around 45% of mineral soils in the EU are estimated to have SOC levels below 2%.
[116] EEA: Briefing "Soil carbon": https://www.eea.europa.eu/publications/soil-carbon accessed 24-Nov-2022
[117] FAO, 2020. Drained organic soils 1990–2019. Global, regional and country trends. FAOSTAT Analytical Brief Series No 4, Rome, accessible at: https://www.fao.org/documents/card/fr/c/cb0489en/ .
[118] EEA (2022) Soil monitoring in Europe- Indicators and thresholds for soil quality assessments.
[119] Panagos, P., Ballabio, C., Scarpa, S., Borrelli, P., Lugato, E. and Montanarella, L., Soil related indicators to support agri-environmental policies, EUR 30090 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-15644-4, doi:10.2760/011194, JRC119220.
[120] EEA: Briefing "Soil carbon": https://www.eea.europa.eu/publications/soil-carbon accessed 24-Nov-2022

It should be noted that these figures (but not the overall conclusion that soils are losing carbon) can be inaccurate, because of monitoring gaps. A recent study estimated that unreported losses could be around 70 million tonnes CO_2/yr in croplands, and unreported gains could be around 15 million tonnes CO_2/yr in grasslands and 45 million tonnes CO_2 /yr in forests.[121]

While low SOC levels may be natural for some soils, it is believed that large areas of cultivated European soils are below their functional thresholds.[122] Among all MAES ecosystem types, cropland soils have the lowest SOC concentrations.[123, 124]

The following map produced by the JRC presents the areas with lower SOC concentration, in the topsoil of mineral soils, compared to the content in grasslands in the same pedoclimatic conditions.



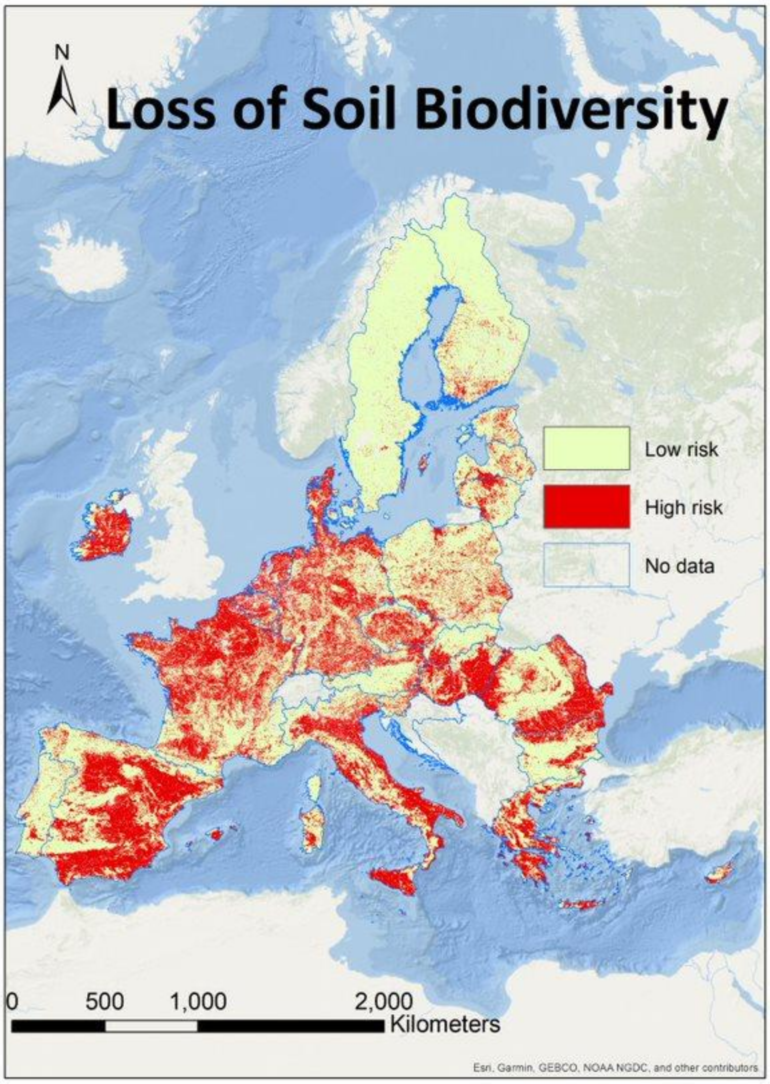
[121] Bellassen, V., Angers, D., Kowalczewski, T. et al. Soil carbon is the blind spot of European national GHG inventories. Nat. Clim. Chang. 12, 324–331 (2022). https://doi.org/10.1038/s41558-022-01321-9
[122] JRC (2012) The State of Soil in Europe.
[123] Costantini et al., (2020) Local adaptation strategies to increase or maintain soil organic carbon content under arable farming in Europe: Inspirational ideas for setting operational groups within the European innovation partnership.
[124] Maes et al (2020) Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment

1.3.1.7 Loss of soil biodiversity

Through the abiotic and biotic interactions, soil biodiversity supports the multi-functionality of soils – underpinning the delivery of soil ecosystem services outlined in section 2.4.1. Soil biodiversity is estimated as being under pressure in 56% of the total EU landmass,[125] whilst 14%-40% being calculated at medium-high potential risk.[126] Orgiazzi et al. (2016) assessed the key threats and pressures to soil biodiversity (classified as soil microorganisms, fauna and biological functions), finding that the intensive use of soil in agriculture was the highest threat to soil biodiversity.[127] Using threats to soil biodiversity as a proxy to highlight where soil biodiversity is likely to be in current decline, Gardi et al. (2013) demonstrated that areas, inter alia, in central Europe, Po valley in Italy were currently exposed to high pressures on biodiversity.[128] A lack of data on current trends of soil biodiversity in the EU exists. The LUCAS Biodiversity component (2018) will contribute to the first continental soil biodiversity assessment across the EU through molecular biology techniques.[129]

The following map produced by the JRC presents the areas with estimated high risk for loss of soil biodiversity

[125] Gardi et al., (2013) An estimate of potential threats levels to soil biodiversity in EU
[126] See footnote 124; Orgiazzi et al., (2016) A knowledge-based approach to estimating the magnitude and spatial patterns of potential threats to soil biodiversity.
[127] See footnote 125, the second reference.
[128] See footnote 124.
[129] Orgiazzi, A., Panagos, P., Fernández-Ugalde, O., Wojda, P., Labouyrie, M., Ballabio, C., Franco, A., Pistocchi, A., Montanarella, L., & Jones, A. (2022). LUCAS Soil Biodiversity and LUCAS Soil Pesticides, new tools for research and policy development. European Journal of Soil Science, 73(5), e13299. https://doi.org/10.1111/ejss.13299



1.3.1.8 Desertification

Desertification is a form of land degradation in drylands and is both a cause and a consequence of climate change. Thirteen EU Member States have declared that they are affected by desertification under the United Nations Convention to Combat Desertification: Bulgaria, Croatia, Cyprus, Greece, Hungary, Italy, Latvia, Malta, Portugal, Romania, Slovakia, Slovenia and Spain.[130] The most recent estimate of sensitivity to desertification in Southern, Central and Eastern Europe in 2017 suggested 25% (411.000 out of 1.7 million km^2) was at High or Very High Risk. This was an increase from 14% in 2008 (Prăvălie et al. 2017).[131] Due to improved data quality, the extent of land under these high risks was 75% more than the previous estimation done in 2008. Almost half of the land area of Spain (~ 240,000 km^2) is deemed highly or very highly susceptible to degradation while large parts of Greece (34%), Bulgaria (29%) and

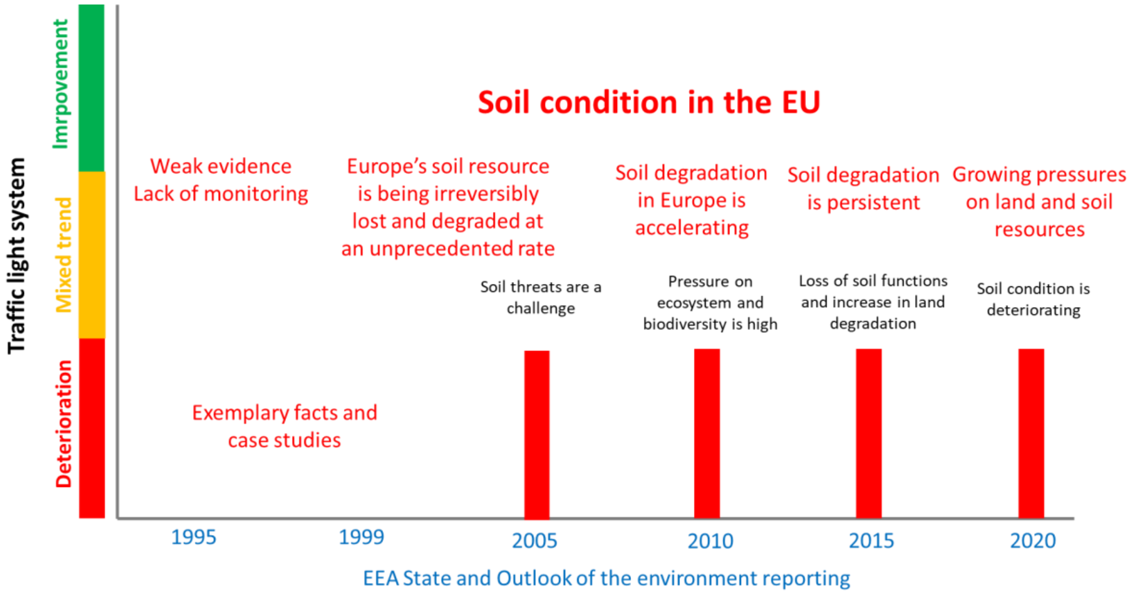
[130] European Court of Auditors (2018) Desertification in the EU.
Available at: https://www.eca.europa.eu/Lists/ECADocuments/BP_DESERTIFICATION/BP_DESERTIFICATION_EN.pdf
[131] Prăvălie, Remus, Cristian Patriche, and Georgeta Bandoc. (2017) "Quantification of land degradation sensitivity areas in Southern and Central Southeastern Europe. New results based on improving DISMED methodology with new climate data." Catena 158: 309-320.

Portugal (28%) are at high risk. There are also concerns for Italy and Romania, where around 10% of their territories are highlighted.

1.3.2 Outlook of the problem

Here is the summary of the assessment of soil condition in the EU as performed by the EEA in its SOERs from 1999 to 2020. It shows that soil condition is increasingly deteriorating.

Figure 1-5: EEA State and Outlook of the Environment Report 1995-2020



2 SUB-PROBLEMS

2.1 Sub-problem A: Data, information, knowledge and common governance on soil health and management are insufficient.

2.1.1 Insufficient information on soil health

The assessment of the quality and health of soils still is a subject of active research and of controversy among scientists, practitioners and Member State authorities. As summarised by the EEA in its report on the monitoring of soil health,[132] the current approach of quantifying the degree of soil health via linkage between critical thresholds and current soil (functional) condition still is hampered by the following factors:

"While various indicators related to soil threats have been proposed over the recent past, specifications for monitoring and evaluation are missing.
There is no consensus yet between countries regarding valid regionalised critical limits used as thresholds for specific soil functions.
The methodology to link a specific threshold (via models) to the current condition in soil, or water, differs between countries or group of countries."

[132] European Environmental Agency (EEA) 2022. Soil monitoring in Europe – Indicators and thresholds for soil quality assessments. ISBN 978-92-9480-538-6. https://www.eea.europa.eu/publications/soil-monitoring-in-europe-indicators-and-thresholds

Despite the intense and high-quality research performed by soil scientists, at the JRC and in other top research centres world-wide, it is therefore difficult to conclude on the condition of the soil and soil health without a common soil health definition and methodology.

Soil data in Europe is centralised in a common repository, ESDAC, which provides extensive datasets on a broad range of topics.[133] However, some data on soil health still is lacking. As recently assessed by the EJP Soil,[134] "Evaluation of soil water retention is one of the less monitored soil characteristics in participating countries. Contamination with organic pollutants is addressed in only about one third of countries. Biological parameters are generally the least frequently evaluated indicators of soil quality in Europe. Biological activity is most often evaluated through soil respiration, but also only in seven of the participating countries."

Furthermore, in a transaction bearing on the sale of a piece of land, there is an asymmetry between the knowledge held by the seller on the condition of the soil on that piece of land (which is relatively higher, based on past empirical experience) and the knowledge of the buyer (which is lower, in the absence of data and of a scientifically stable assessment method). This lack and asymmetry of information reduces the incentives for landowners to have good soil management practices, as the detrimental consequences of these will be difficult to detect by a buyer, and hence will have minimal consequences on the selling price. Conversely, the uncertainty on the soil health on the side of the buyer reduces his/her willingness to pay and has land prices to decrease compared to what would be possible if reliable information were available, following a general phenomenon on markets in situations of uncertainty.[135]

2.1.1.1 Knowledge gaps

The gaps in knowledge on soils relate to all elements of the chain between information and action:

- The nature of the indicators that are relevant and necessary to assess the condition of soils remains an open scientific question;
- The threshold values for these indicators to qualify the health as 'good' are also the purpose of scientific debate;
- The data collected on the condition of soils is insufficiently comprehensive in terms of some indicators, geographic coverage in the EU and of sampling frequency;
- The technologies to remediate deteriorated or contaminated soils still require further development to reduce their economic and environmental costs, and to improve their efficiency.

These gaps exist for specialists in soils. The knowledge level of the general public, and even of land managers themselves, is considerably lower.

[133] https://esdac.jrc.ec.europa.eu/

[134] EJP Soil "Towards climate-smart sustainable management of agricultural soils, Deliverable 2.2: Stocktaking on soil quality indicators and associated decision support tools, including ICT tools", 2021, Available at: https://ejpsoil.eu/fileadmin/projects/ejpsoil/WP2/Deliverable_2.2_Stocktaking_on_soil_quality_indicators_and_associated_decision_support_tools__including_ICT_tools.pdf

[135] Akerlof, G. A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism. The Quarterly Journal of Economics, 84(3), 488–500. https://doi.org/10.2307/1879431

Despite the ca. 200,000 EU citizens having supported the European Citizens' Initiative 'People4Soil' in 2016-2017,[136,137] the general population tends to be unaware of the importance of soils, with increasingly urbanised population often seeing it as dirt and as an unlimited natural resource, often unaware of its relevance in their daily lives and of its key role for achieving a sustainable and circular bioeconomy.[138,139] In turn, if soil health is not a priority for citizens, it is consequently much less likely to be a priority for their elected representatives, especially as soil policies may incur immediate costs with only longer-term benefits.

Similarly, a study that reviewed a number of academic papers analysing the determinants of farmers' behaviour and decision-making[140] found that pro-environmental attitudes, goodness of fit (with existing management practices and fit with legal obligations), and past experience are consistently found as having a role to play in farmers' decision-making. However, the authors recognised that there are hardly any studies of farmers' decision-making behaviour that can be clearly linked to soil management and soil pressures.

As a consequence of these two issues, action to tackle unhealthy soils and prevent further degradation is not taken or insufficiently taken.

2.2 Sub-problem B: Transition to sustainable soil management and restoration, as well as remediation is needed but not yet systematically happening, e.g. for the unsolved legacy of contaminated sites.

For reasons detailed in the section on 'What are the problem drivers', the management of EU soils is not sufficiently sustainable. This insufficient sustainability of soil management takes the following aspects.

2.2.1 Unsustainable soil management

Some agricultural and forestry practices are known to be detrimental to soil health. These practices include:

- Intensive tillage (leading to loss of Soil Organic Carbon in topsoils);[141]
- The usage of heavy machinery,[142,143] and high stocking densities, specifically on wet soil on agricultural or forest land (leading to soil compaction);
- Insufficient land cover by vegetation[144] (leading to erosion);

[136] https://www.arc2020.eu/citizens-demand-soil-action/
[137] https://europa.eu/citizens-initiative/initiatives/details/2016/000002_en
[138] EU Soils Strategy
[139] Heuser, I.L. (2018). Development of Soil Awareness in Europe and Other Regions: Historical and Ethical Reflections About European (and International) Soil Protection Law. In: Ginzky, H., Dooley, E., Heuser, I., Kasimbazi, E., Markus, T., Qin, T. (eds) International Yearbook of Soil Law and Policy 2017. International Yearbook of Soil Law and Policy, vol 2017. Springer, Cham. https://doi.org/10.1007/978-3-319-68885-5_24
[140] Bartkowski B, Bartke S. Leverage Points for Governing Agricultural Soils: A Review of Empirical Studies of European Farmers' Decision-Making. Sustainability. 2018; 10(9):3179. https://doi.org/10.3390/su10093179 https://www.mdpi.com/2071-1050/10/9/3179
[141] Nunes, M et al. (2020) 'Biological Soil Health Indicators Respond to Tillage Intensity: A US Meta-Analysis', https://doi.org/10.1016/j.geoderma.2020.114335
[142] Osman (2014). Soil degradation, conservation and remediation.
[143] Keller and Or (2022) 'Farm vehicles approaching weights of sauropods exceed safe mechanical limits for soil functioning', Proceedings of the National Academy of Sciences.
[144] Zhou et al. (2008); 'Effect of vegetation cover on soil erosion in a mountainous watershed'.

- Clear felling of forests and overgrazing of pastures[145] (leading to a reduction in the plant cover and in the protection of the soil against solar heat and sunlight, against wind, and against water erosion);
- Use of slurries and manure with high readily available N outside of periods of active crop growth (leading to nutrient leakage);[146]
- Excessive usage of pesticides (leading to excess concentration of residues in soils and impact on soil biodiversity);[147]
- Excessive usage of fertilisers and of manure (leading to nutrient losses to air and water, as well as soil acidification, ultimately reducing soil fertility in the longer term).[148]

2.2.2 Land use change

In general, the health of soil deteriorates as land use evolves along the following set of stages:[149]

- Primary vegetation cover, including wetland and peatland;
- Secondary forest;
- Grassland;
- Agricultural land;
- Unsealed artificial area (e.g. parking or pathway);
- Sealed land.

When land use changes from one stage of this ladder to a lower one, because of human intervention, then soil health generally deteriorates due to changes in the physical, chemical and biological properties, generally as a result of soil disturbance.

Table 2-1 displays the evolution of soil surface in the EU (the current 27 Member States, without Croatia, and including the United Kingdom) under each nature of land cover, from 2012 to 2018.

Table 2-1: Land cover in the EU 2012-2018, in % of total surface

Land cover	2012	2015	2018
Artificial land	4	4,2	4,4
Cropland	22,8	22,3	23,9
Woodland	37	37,6	39,5
Shrubland	7	7,1	6
Grassland	21,6	20,8	18,8
Wetland	1,6	1,7	1,8

Source: Eurostat, based on LUCAS survey. Land cover overview by NUTS 2 regions [lan_lcv_ovw]

It shows that the share of artificial land has increased by 10% in 6 years, which translate in 14,672 km^2 of soil lost to artificial land over this period.[150]

[145] Nunes et al. (2020) 'Biological Soil Health Indicators Respond to Tillage Intensity: A US Meta-Analysis',
[146] See footnote 144.
[147] See footnote 144.
[148] See footnote 144.
[149] Ramesh et al.(2019); 'Chapter One - Soil organic carbon dynamics: Impact of land use changes and management practices: A review', Advances in Agronomy, https://doi.org/10.1016/bs.agron.2019.02.001
[150] Eurostat (2022), based on LUCAS survey. Land cover overview by NUTS 2 regions [lan_lcv_ovw]

The soil being **excavated** for the sake of land take is only partially recycled. In 2020, the EU excavated a total of 434.6 million tonnes of non-hazardous soils, of which 154.8 million tonnes (i.e. 35.6%) were recycled and thus used for their biological properties and capacity to provide ecosystem services, eliciting the existence of dedicated soils recycling companies.[151] Consequently, 173 million tonnes of non-hazardous excavated soils were used for backfilling, i.e. only for the volume that they occupy, and 106.6 million tonnes simply landfilled, in both cases having their biological productive capacity wasted.[152]

2.2.2.1 Urban sprawl and spatial development

Most economic activities outside of agriculture and forestry are performed on sealed or artificial land: surface installations of underground mining and quarrying, manufacturing, transport, logistics, parking, retail, tertiary activities, housing, education, and public administration. Some of these developments are performed on existing sealed soils (e.g. in former industrial or military terrains, also called 'brownfields'), but a significant fraction is performed by sealing natural areas, agricultural land, forest or grassland.

The sealing of land directly destroys the soil ecosystem under it. In general, the soil and upper subsoil is compacted or excavated before the construction takes place, in order to establish the foundations of the construction or of the infrastructure on a mechanically reliable and stable substrate.

In addition, open-pit mining and quarrying proceed by excavating the soil and the upper layers of the subsoil to access the mineral ore or rocks of interest.

When excavated to make place for construction, the infrastructure, the open pit mine or the quarry, the soil, even if uncontaminated, is often considered as waste[153] and is subsequently essentially being dumped in landfills without being re-used for its functional capacity to provide any ecosystem service (for example 49% of uncontaminated soils were landfilled in 2016 in Sweden, 98% in Norway and Slovenia in 2018, but 17% in Portugal in 2017), as seen above.[154]

The pressure for more land take is considerable, and due to the combination of: (1) demographic trends (including population growth and urbanisation), and (2) individual preference for detached housing. Albeit at a small rate, the EU population keeps on growing (3% in EU+UK in 2012-2018),[155] which leads to increased demand for housing, with a risk of increased soil sealing. Urbanisation is also projected to increase, with a 11% increase foreseen by 2050. Urban expansion is accompanied by a greater need for infrastructure (transport, water, waste and electricity), which decreases the long-term availability of productive land resources.[156] Although new urban development tends to develop around this infrastructure, it is important to note that strong public transport networks in cities can, in the long-term, lead to less urban sprawl.[157] In addition,

[151] E.g.: https://www.boughton.co.uk/soil-collection-recycling-services/ E.g.: https://www.boughton.co.uk/soil-collection-recycling-services/
[152] Eurostat (2022) Treatment of waste by waste category, hazardousness and waste management operations[env_wastrt]
[153] Directive 2008/98/EC of 19 November 2008 on waste
[154] Hale et al. 'The Reuse of Excavated Soils from Construction and Demolition Projects: Limitations and Possibilities'
[155] https://www.eea.europa.eu/publications/land-take-and-land-degradation
[156] https://www.eea.europa.eu//publications/soer-2020
[157] https://www.sciencedirect.com/science/article/abs/pii/S026483771830855X

urbanisation can lead to an endangering of the conservation of high nature farmland in rural areas or to land abandonment, although the latter could offer opportunities to re-wild parts of abandoned areas.

The widespread preference for detached housing and one-family accommodation also leads to increased land take.[158,159] In the Netherlands, one of the smallest EU countries and with the second-highest rate of land take in the EU in 2000-2018,[160] housing-market research shows that over 80% of intentional movers prefer a house with an attached garden, with many indicating that they would not move to a house without a garden. The Covid-19 pandemic is likely to have reinforced these trends. A 2020 study showed that outdoor space is ranked amongst citizens' top 5 priorities across EU regions and has become extremely important for an additional 27% since the pandemic, with now over 60% of people judging a personal outdoor space as extremely important. More generally speaking, the pandemic has heightened people's appreciation for good quality homes which meet their expectations.[161]

Moreover, a study assessing whether this preference for private gardens could be substituted by public green space showed that the private domestic garden cannot simply be substituted by public green space as these hold different functions in the eyes of residents.[162]

2.2.2.2 Improper water management

Excessive irrigation and uncareful drainage, specifically in coastal areas, leads to the salinisation of groundwater, by infiltration of sea water in the aquifer, and subsequently of the soil.[163]

2.2.2.3 Causes of site contamination

Human industrial, transport, storage or waste management activities lead, unless specific precautions are taken, lead to the leakage of pollutants to soils, air and water, during normal operations or upon accidents. Because of the persistence of pollutants in soils, many areas suffer from current or recent contaminating practices, but also from a full legacy of contaminating practices over the whole history of the site, since the start of the industrial revolution. More specifically:

- Industrial pollutants (such as heavy metals, POPs such as Polycyclic Aromatic Hydrocarbons (PAHs), liquid fuels and other hydrocarbons) are or have been released on the ground, with insufficient or no treatment, because of ignorance or neglect. This is particularly true for those legacy sites contaminated before the entry into force of the Industrial Emissions Directive (IED) in 2007;
- Industrial pollutants also leak or have leaked from containers because of improper maintenance or storage conditions, or of accidents, during road or rail transport or at their industrial storage site;

[158] https://www.eea.europa.eu/publications/land-take-and-land-degradation
[159] https://www.sciencedirect.com/science/article/abs/pii/S026483771830855X
[160] https://www.eea.europa.eu/data-and-maps/indicators/land-take-3/assessment
[161] https://residential.jll.co.uk/insights/research/housing-needs-and-resident-preferences-across-europe-during-covid-19
[162] https://link.springer.com/article/10.1007/s10901-011-9246-5#Sec19
[163] Mastrocicco, M.; Colombani, N. The Issue of Groundwater Salinization in Coastal Areas of the Mediterranean Region: A Review. Water 2021, 13, 90. https://doi.org/10.3390/w13010090

- Industrial and domestic (solvents) pollutants leak or have leaked from legal or illegal waste landfills, specifically of hazardous waste;
- Insufficiently treated urban wastewater is or has been released in the groundwater or in water bodies while still containing pollutants (solvents, pharmaceuticals).

2.2.2.4 Estimation of the number of contaminated sites and of their condition

The number of countries in the remit of the EEA which report statistics on contaminated sites has increased from 20 in 2006 to 23 in 2016. However, 10 MS still have either not yet developed any national register of contaminated sites and/or consider only a very limited set of polluting activities in their management approaches. Consequently, the data on contaminated sites remains subject to important uncertainties.

For the EU-28, the JRC published an estimate in 2018 of around 2.8 million sites where polluting activities took/are taking place, so potentially contaminated. That study provides estimations of the number of sites registered, under investigation, and based on their remediation status, using data from reports by Member States. However, as these reports use differing methodologies and as the data is over 10 years old, these figures are not presented in the present report.[164]

Based on national registries summarised in a report recently published by the EEA, in 2016, 1.38 million potentially contaminated sites are currently registered, largely in 11 countries.[165] Sites become registered once a suspicion for a polluting activity is confirmed, at average 69 % of all estimated sites. Based on a projected total of 2.8 Mio sites with an expectation that at least 2 Mio registered sites could be expected once national registers would be fully and comparably developed. It is estimated that 2/3 of contaminated sites – with large national differences – could be historic (e.g. brownfields and orphan sites), i.e. not covered by the current legislation on the prevention of industrial pollution (Industrial Emissions Directive and European Pollutant Release and Transfer Register).

According to the same study, in 2016, 115,000 contaminated sites were remediated in the EU, representing 8.3 % of the currently registered potentially contaminated sites. Based on the current projections, at least 166,000 additional sites can be expected in need for risk reduction measures or remediation.

3 WHAT ARE THE PROBLEM DRIVERS?

3.1 Market failures

3.1.1 Market failure: Insufficient + heterogeneous internalisation of environmental costs in EU + third countries

The costs caused by practices harmful to soils are often not borne by those who benefit from them, in a phenomenon known as ‘externalities’. Whereas the benefits of harmful

[164] Joint Research Centre (2018), Status of local soil contamination in Europe https://publications.jrc.ec.europa.eu/repository/handle/JRC107508
[165] EEA (December 2022) Progress in the management of contaminated sites in Europe https://www.eea.europa.eu/ims/progress-in-the-management-of

practices are generally concentrated with the current landowner, its costs are borne by stakeholders that are distant in time (in the future, over several generations), in their social or economic condition or in space, including in other Member States of the EU.

The textbook answer to externalities is to evaluate and internalise these external costs, in order to incentivise the actors towards taking them into account in their practices.

Despite the very high costs of soil degradation, so far, few legally-binding requirements are in place to internalise the external costs of practices harmful to soils. The exceptions are the EU national legislations listed in the baseline scenario (**Error! Reference source not found.**). These legislative dispositions have an effect, but which appears to be insufficient to prevent the occurrence of the practices harmful to soil health.

The SoilEX database[166] managed by the FAO provides an overview of soil legislation existing around the world. For instance, Australia has a very comprehensive set of laws to protect soils, starting with a Soil Conservation Act of 1938,[167] and Switzerland has adopted in 2006 a Soil Protection Ordinance[168] implementing its Environmental Protection Act (EPA).[169] Some examples are also found in developing countries, such as the 1951 Soil Conservation Act in Sri Lanka (last amended in 1953), the 1953 Land Planning and Soil Conservation Act of Ghana (last amended in 1957) and the 1987 Soil and Watershed Conservation Act in Nepal (last amended in 2010). Another example of successful policy not listed in the FAO database is the US Soil Conservation Act of 1935, which gave farmers monetary subsidies to plant vegetation other than commercial crops in order to address the depletion of nutrients in soils linked to over-farming. After four years, wind-inflicted soil erosion was reduced by 65%.[170] Nevertheless, as aforementioned soil degradation continues to be a problem affecting billions of people worldwide and with significant economic consequences.[171]

Managers of land generally sell on commodities markets (agricultural or forestry products), in a competition, mainly set on price, where those paying the least of the external costs get an advantage. The fear of being undercut on costs by international competitors not subject to the same obligations regarding the internalisation of external costs to soil health leads land managers to adopt or retain harmful practices.

3.1.2 Market failure: The financial gains of land take are considerably larger than the value of ecosystem services provided

The benefits of land take and land sealing are larger (sometimes by orders of magnitude) than the loss of ecosystem services that this land take or land sealing induces, even in the hypothetical case where these would be fully integrated into a perfectly enforced polluter pays scheme, not only in the short term, but also in any foreseeable future. This is because the economic value of the activities being performed on the land taken is much larger than that of the ecosystem services provided by that same piece of land when that piece of land remains untouched. This is a typical case of market failure, where the rational computation performed using the marginal cost and benefit, as evaluated at the

[166] https://www.fao.org/soils-portal/soilex/en/
[167] https://www.fao.org/faolex/results/details/en/c/LEX-FAOC002846/
[168] https://leap.unep.org/countries/ch/national-legislation/soil-protection-ordinance
[169] https://www.fedlex.admin.ch/eli/cc/1984/1122_1122_1122/en
[170] https://reference.jrank.org/environmental-health/Soil_Conservation_Act_1935.html
[171] https://zenodo.org/record/3237411#.Y34_AHbMI2w

small scale of each individual actor, leads to decisions that, when aggregated, are collectively negative.

Whereas the ecosystem services provided by soil are estimated at 39.15 kEUR/km^2/yr,[172] i.e. 391.5 EUR/ha/yr or 0.039 EUR/m^2/yr, the value of economic activities susceptible to be performed on the same surface ranges between ca. 1,800 EUR/ha/yr for agriculture[173] (i.e. 5 times above the value of ecosystem services), 60 to 150 EUR/m^2/yr for rental of social housing[174] (i.e. between 1,500 and 4,000 times more than the value of ecosystem services) and even more in the case of rental for economic activities such as office space.[175] Similarly, the value of open mining (estimated at covering 12,416 km^2 in 2018 in EU-27[176]) is considerably higher than that of the ecosystem services provided on the same surface. In the case of Germany, the yearly production of lignite is stable at 171.5 million t/yr in 2017.[177] Extrapolated over 50 years (as an order of magnitude, considering that lignite mining started earlier than in 1972, but at a rate lower than that of 2017), and with an order of magnitude for the price of 400 EUR/t,[178] the total production of lignite performed in Germany can be estimated at 3,430,000 MEUR, on a total excavated surface of 117,300 ha[179], leading to a lignite production value of 29 MEUR per hectare, i.e. ca. 75,000 times higher than the value of ecosystem services provided on the same surface.

3.1.3 Market failures: differences in time horizons and discounting rates between economic actors

Soil formation has very low rates, meaning that it is considered as a non-renewable resource from human perspectives, which ideally should be maintained indefinitely intact for all future generations. As such, the time horizon of a responsible public policy, considering the public interest of all involved parties, including future generations, should be infinite, and the resulting discounting rate equal to zero (i.e., the value of the benefits which accrue after a long time period should not be lower than the value of the benefits that can be obtained now).

Economic operators however, and humans in general, do not reason with such long-time horizons, and tend to discount future costs and benefits at rates that are strictly positive, with differences among them:

- Land tenants tend to limit their time horizon to the duration of their tenure, which generally lies in the range of 10 years. In addition, they often need to borrow and repay (considerable) loans to be able to operate (purchase of

[172] Vysna, V., Maes, J., Petersen, J.E., La Notte, A., Vallecillo, S., Aizpurua, N., Ivits, E., Teller, A., Accounting for ecosystems and their services in the European Union (INCA). Final report from phase II of the INCA project aiming to develop a pilot for an integrated system of ecosystem accounts for the EU. Statistical report. Publications office of the European Union, Luxembourg, 2021.
[173] Total value of agricultural goods output in the EU 27 for the year 2019: EUR 344.6 bn. (source Eurostat Economic accounts for agriculture - values at real prices [aact_eaa04]); Utilised Agricultural Area in the EU 27 for the year 2019: 184 Mha, leading to an average value produced per hectare equal to 1,873 EUR/hectare.year.
[174] Housing Europe, 2021: “Cost-based social rental housing in Europe, the cases of Austria, Denmark, and Finland”, downloadable at: https://www.housingeurope.eu/file/1073/download .
[175] BNP Real Estate, 2020, Eruope Office Market 2020, downloadable at: https://www.realestate.bnpparibas.com/sites/default/files/2020-03/Euro-Office-Market-2020.pdf
[176] Note, this is land *use* rather than land take. Data from: EUROSTAT (2022) Land use overview by NUTS 2 regions. Available at: https://ec.europa.eu/eurostat/databrowser/view/LAN_USE_OVW__custom_4142165/default/table?lang=en
[177] Source: German federal ministry for economic affairs and climate protection BMWK https://www.bmwk.de/Redaktion/EN/Artikel/Energy/coal.html
[178] Reference: export price of US lignite, accessible at https://www.indexbox.io/blog/lignite-price-per-ton-june-2022/
[179] Source: German federal ministry for economic affairs and climate protection BMWK https://www.bmwk.de/Redaktion/EN/Artikel/Energy/coal.html

machinery, equipment, etc.), which incentivises them to favour shorter-term returns without considering longer-term damage to soils;

- Landowners limit it to the duration of their ownership, which for owners exploiting their land directly used to be a lifetime or that of their immediate descendants, but may be significantly shorter for financial investors seeking liquidity and shorter-term speculative gains (notably, the issue of loan repayment may also apply here);
- Companies depending upon specific agricultural inputs (e.g. from Protected designation of origin – PDO,[180] such as Bordeaux or Champagne wine) have a long-term interest in preserving the quality of the local soil over the time horizon of their shareholders, which can be very long for family-owned companies.

A case study in the Netherlands on the different actors in sustainable soil management highlights the differences in interests related to soil management among actors.[181] In this study the actor inventory was structured around the value chain of the farmer and 12 sub criteria for sustainable soil management had to be rated by these actors (30 in total). Many of the actors such as dairy farmers, arable farmers, intensive livestock farmers, technology suppliers, farmers organisations and landowners express a clear interest in economic incentives, while real estate and land agents, soil sampling providers, water users, water boards, nature managers and regional governments assessed high priorities to environmental sub criteria.

3.1.4 Market failure: Asymmetry of information on soil health

As noted in Sub-problem A (section 2.2.1), information, data and common governance on soil health and management is lacking or incomplete.

It is therefore difficult to establish standardised procedures for soil assessment, taking into consideration the inherent complexity and the natural soil types.

Furthermore, as mentioned above, in a transaction bearing on the sale of a piece of land, there are aspects of soil health (such as soil pollution) where an asymmetry exists between the knowledge held by the seller on the condition of the soil on that piece of land (which is relatively higher, based on past empirical experience) and the knowledge of the buyer (which is lower, in the absence of data and of a scientifically stable assessment method), leading to market inefficiencies.

On the other hand, when correct information is known on the management of the soil, a price premium between 10 and 22% can appear for sustainably managed soils.[182]

3.2 Regulatory failure

There is no dedicated EU instrument which protects soils like the ones existing for other media such as air and water.

[180] https://ec.europa.eu/info/food-farming-fisheries/food-safety-and-quality/certification/quality-labels/quality-schemes-explained_en
[181] https://edepot.wur.nl/546905
[182] Telles, T. S., Maia, A. G., & Reydon, B. P. (2022). How soil conservation influences agricultural land prices. Agronomy Journal, 114, 3013– 3026. https://doi.org/10.1002/agj2.21091

Despite numerous provisions enshrined in existing EU legislation which are of relevance for soils, there is a **clear and indisputable gap within the current EU legal framework** (see **gap analysis in annex 6** for further details). Due to their different objectives and scopes, and to the fact that they often aim to safeguard other environmental media, existing provisions, even if fully implemented, yield a fragmented and incomplete protection to soil, as they do not cover all soils and all soil threats identified.

There is also a lack of definitions, indicators and ranges to define the notion of "healthy soils" and there is currently no obligation to monitor all aspects of the health of soils. The assessment of the quality and health of soils is a subject of active research and of long-lasting controversy among scientists, practitioners and Member State authorities. It is therefore difficult, without a commonly agreed soil health definition and of indicators to measure it, to conclude on the condition of a soil.

Furthermore, there is a lack of binding policy targets and some threats to soil such as land take, compaction, erosion, salinisation and soil sealing are not addressed in existing European legislation.

There is a gap regarding the non-deterioration of soils since there is currently no legal obligation to require soil health does not deteriorate, or to manage soil sustainably. There is also a gap regarding restoration of soils that have deteriorated.

In addition, there is a lack of binding policy objectives relating to soil as such, and this is not covered by the objectives put in place for other areas such as air and water.

Soil degradation still can occur due to insufficient enforcement of existing legislation. One example is waste legislation. In 2021, the Commission has taken legal steps against Romania, Bulgaria, Croatia, Greece and Slovakia for failing to comply with EU laws on waste, and more specifically with the treatment of waste before landfilling (the Waste Framework Directive and the Landfill Directive). Moreover, the ECA identified eight projects in Campania (Italy) that received 27.2 million EUR of EU funds to clean pollution from landfill sites dealing with municipal waste, that occurred when EU environmental legislation was already in force. The pollution occurred because the public authorities responsible for overseeing these sites did not oblige these operators to clean their pollution.[183] The presence of illegal landfills in some EU countries is also problematic. This issue was documented in the latest evaluation of the Landfill Directive in 2007,[184] and seems to persist in some MS such as Slovakia[185] and Bulgaria.[186]

In addition to waste legislation, another example is the weak enforcement of planning regulations in some EU MS.[187] For instance, France's National Institute for Agricultural Research (INRA, replaced in 2020 by the INRAE) noted that although urban planning law and rural law provide measures to protect areas identified as agricultural and that these measures can be considered effective, weaknesses in their implementation and in their design are observed (system of exceptions, no regulation on soil artificialisation justified by agricultural land use).[188]

[183] https://www.eca.europa.eu/Lists/ECADocuments/SR21_12/SR_polluter_pays_principle_EN.pdf
[184] https://ec.europa.eu/environment/pdf/waste/study/cowi_report.pdf
[185] https://ec.europa.eu/environment/pdf/waste/framework/SK_factsheet_FINAL.pdf
[186] https://www.dw.com/en/my-europe-illegal-garbage-dumps-reflect-eus-east-west-divide/a-52480168
[187] https://www.sciencedirect.com/science/article/abs/pii/S026483771830855X
[188] Inra (2017) Artificialisation des sols – synthèse

This latter point relates to another major regulatory failure: in some instances, there is insufficient legislation at national level to ensure the health of soils, meaning that even if all existing legislation was appropriately implemented and enforced, soil health would not be achieved.

Regarding national legislation, an analysis of MS legislation and policy instruments on soils conducted in 2017 recognised that some mechanisms exist in some MS that address EU-level legislation gaps (in particular to define contaminated sites, coordinate action on historic contaminated sites and their identification) and that some MS have put in place comprehensive soil protection legislation. However, the report concluded that for the majority of MS, coverage of key EU legislation gaps is partial and that some MS even lack coordinated actions on soil protection and soil threats.[189] The uneven and fragmented response by MS to tackle soil degradation is mentioned in the EU Soil Strategy, which notes that this has led to an uneven playing field for economic operators who must abide by different rules while competing on the same market.

Three notable examples of insufficient legislation on soil at national levels are rules on contaminated soil and on land take, as well as the insufficient integration of the polluters pay principle. Regarding contaminated soil, a very small fraction of all chemicals that can contaminate soils are regulated under national legislation via contaminant thresholds, and other important policies that could remedy to the issue, such as maintaining a register of contaminated sites or assessing risks and remediating sites in case of inacceptable risks are also lacking.[190]

The increase of land take can relate to insufficient regulation, insufficient coordination across municipalities, and/or inadequate regulations which have the adverse effect of increasing land take. As a result of insufficient planning regulation, decisions regarding urban sprawl taken at the local level can result to new land being allocated to development, as municipalities can be subjected to a lot of pressure to convert agricultural land into housing or commercial/industrial surfaces. In addition, land take can be influenced by a lack of coordination or even competition between municipalities, with municipalities either acting in their own interests by developing land, or with limit on urban development in one municipality leading to urban sprawl in nearby ones. The problem of land take can also be exacerbated by regulations promoting a reduction in urban density, clustering regulations (which mandate to limit the impervious surface on a lot), or subsidies for new housing, new urban development or transport can encourage land take/sprawl).[191,192]

Another example of such an issue are situations of conflict of interest, which can occur when the persons or organisations in charge of allocating land use (typically in sub-urban municipalities under pressure of urban sprawl) are themselves owning land and can expect considerable monetary gains by allowing a conversion of agricultural land to a usage leading to its sealing. The regulatory failure here lies in the governance system on land use, which allows the decision-makers to be direct beneficiaries, as landowners, of the decisions that they take as representatives of the public interest in land planning.

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[189] Ecologic (2017) 'Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States'. Final report.
[190] EU Soils Strategy
[191] https://www.sciencedirect.com/science/article/abs/pii/S026483771830855X
[192] https://www.eea.europa.eu/publications/land-take-and-land-degradation

Finally, as the polluter pays principle (PPP) is insufficiently included in legislation, the losses of eco-systemic services linked to soil degradation are insufficiently integrated into the economic optimisation of economic actors. This can create a "tragedy of the commons" situation,[193] whereby an individual or an organisation is able to deplete a resource for his/her short-term personal interest, even if the resource could be commonly and sustainably managed in the longer-term.[194] This problem has been described by the European Court of Auditors (ECA) specifically in relation to soil pollution. They state that as many polluting activities took place over a long time ago, a high risk exists that polluters no longer exist, cannot be identified, or are insolvent, which creates difficulty for holding them accountable for past pollution for which they are responsible. Moreover, the PPP is difficult to apply in cases of diffuse soil contamination because of the inherent difficulty to attribute liability to specific polluters, therefore creating a difficulty to allocate responsibility for current pollution as well. Despite these difficulties inherent to the problem at hand, and relying on examples from Portugal and Italy, the ECA argues that insufficient regulation on PPP is to blame for some MS' inability to make polluters pay, which leads to significant remediation costs to be borne by public authorities.[195]

Despite soil being under our feet, and hence in theory one of the areas of investigation the easiest to access, it has been very much under-researched compared to other ecosystems. As an illustration, the "Soil Mission" in the flagship Horizon Europe programme received annual funding of EUR 62 million in 2021, and of EUR 95 million in 2022,[196] i.e. between 4.8% and 7% of the yearly expenditures under the Cluster 6 'Food, Bioeconomy, Natural Resources, Agriculture & Environment' of this same programme (EUR 8,952 million over 7 years, i.e. EUR 1,278 million on average per year). Consequently, the technical solutions proposed to maintain, improve or restore soil health remain difficult to implement, as the exact conditions for their success (e.g. soil type, climate, pH) are not fully researched or understood.[197]

3.3 Behavioural biases

3.3.1 Bad anticipation of threshold effects

Issues related to soil health degradation can be difficult to identify. A major difficulty stems from the fact that changes in soil are not always clearly and immediately perceptible, but instead often comes to light indirectly through alterations to other elements (water, air, flora, fauna). This is also perceived with considerable temporal delay, which is due to the storage and buffering capacity of soils,[198] the heterogenic and density nature of soils (not a transparent fluid like air and water), and the relationship

[193] The concept of the 'tragedy of the commons' initially originates from a 1833 essay written by William Foster Lloyd, who used a hypothetical example of the effects of unregulated grazing on common land, but was coined by Garrett Hardin in 1968 who used this example to explain the tendency of individuals to misuse common goods for short-term, personal interest.
[194] Ostrom, E. (1990). Governing the Commons: The Evolution of Institutions for Collective Action (Political Economy of Institutions and Decisions). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511807763, summarised here: https://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/5887/tragedy%20of%20the%20commons%20_%20Th...pdf?sequence=1&isAllowed=y
[195] https://www.eca.europa.eu/Lists/ECADocuments/SR21_12/SR_polluter_pays_principle_EN.pdf
[196] https://rea.ec.europa.eu/funding-and-grants/horizon-europe-cluster-6-food-bioeconomy-natural-resources-agriculture-and-environment/soil-mission_en
[197] Buckwell, A., Nadeu, E., Williams, A. 2022. Sustainable Agricultural Soil Management: What's stopping it? How can it be enabled? RISE Foundation, Brussels.
[198] https://link.springer.com/chapter/10.1007/978-3-319-68885-5_24

between soil condition and ecosystem services being provided (i.e., ecosystems tend to self-stabilise when remaining in their zone of viability, until they are no longer resilient). As a consequence of such delayed identification on soil health degradation until it is often presented in a highly unhealthy state, the tipping point is often reached and the system can be found near collapse.

The same effect arises regarding soil loss. As long as the soil horizon is sufficient to grow crops, soil losses are not perceived in yield differences in the short term. Farmers can then have a short-term bias due to a non-linear dependency of yields to soil health. They may tend to consider that the soil erosion is of limited importance, until the moment when the remaining soil horizon is below what would be required to grow crops – when the impacts on yield become very important, but when it is also generally too late to act.

In addition, the action of the stakeholders towards better soil health is limited by two cognitive barriers:

- Their awareness of the existence and of the magnitude of the problem is limited. As stated in a JRC study on a French case[199] "*The first (factor limiting the implementation of soil conservation policies) is the lack of knowledge, extended to all stakeholders, on the functioning of agricultural soils*". Similarly, the European Academies Science Advisory Council concluded in its report on soils[200] that "*the increasing spatial disconnect between consumers and the ecosystems that produce the food and other commodities on which they depend can lead to a lack of awareness and understanding of the implications of consumption choices for land degradation*";
- The conditions needed for a given action to have a positive effect on soil health depend on many variables (e.g. soil type, climate, pH), in a complex relationship.[201] In the absence of competent and trusted advisory services able to guide the land manager towards practices that are both environmentally sustainable and compatible with his/her own economic interests, such complexity creates a significant barrier to the adoption of more sustainable practices.

4 CONSEQUENCES OF THE PROBLEM

4.1 (first order) Consequences on the delivery of ecosystem services

4.1.1 Introduction

Soils provide the following ecosystem services:[202]

1. food and biomass production, including in agriculture and forestry;
2. absorb, store and filter water;
3. transform nutrients and substances, including dead biomass and excreta;

[199] JRC project SoCo "Sustainable agriculture and soil conservation', Case Study Report (WP2 findings) – France (2008) https://www.yumpu.com/en/document/view/21925908/case-study-report-wp2-findings-france-european-soil-portal
[200] EASAC "Opportunities for soil sustainability in Europe" (2018) https://easac.eu/fileadmin/PDF_s/reports_statements/EASAC_Soils_complete_Web-ready_210918.pdf
[201] Buckwell et al., (2022) Sustainable Agricultural Soil Management: What's stopping it? How can it be enabled? RISE Foundation, Brussels.
[202] Adapted from: EU Soil Strategy for 2030 Reaping the benefits of healthy soils for people, food, nature and climate - COM(2021) 699 final

4. provide the basis for life and biodiversity, including habitats, species and genes;
5. act as a carbon reservoir;
6. provide cultural, recreational and health services for humans;
7. provide a physical platform for human settling and activities;
8. act as a source of raw materials;
9. constitute an archive of geological, geomorphological and archaeological heritage.

The last three ecosystem services in this list are related to the mineral composition of soils, and are thus extremely stable:

- physical platform for human settling and activities;
- source of raw materials;
- archive of geological, geomorphological and archaeological heritage.

They will thus not be further considered.

The ecosystem services in the list depend upon the existence and health of the live ecosystem embedded in soils, and hence also on the size and connectivity of the cavities in soils, and on the water and dissolved ions present therein.

4.1.2 Reduced fertility of EU soils for agriculture

It is estimated that between 61% and 73% of agricultural soils are affected by erosion, the loss of organic carbon, nutrient (nitrogen) exceedances, compaction or secondary salinisation (or a combination of these threats).[203] These degradations can significantly impact the fertility of agricultural soils, which can ultimately impact the yields generated from such soils. Each of these degradations and their impacts on crop yields are discussed below.

Unsustainable soil erosion (when erosion occurs at a rate higher than soil formation) can negatively impact crop yields through the removal of organic matter and nutrients within the topsoil. A study by Panagos et al. (2018) estimated that the total economic loss in agricultural productivity due to soil erosion in the EU at EUR 1.2 billion in 2010 – 8% of crop yields in areas with severe erosion.[204] Soil erosion can exacerbate the loss of **soil organic carbon** which in turn leads to changes in soil nutrient availability, structure, and water retention capabilities. Global studies have shown that soil organic carbon concentrations between 0.1-2% produce the greatest yield impacts – beyond 2% the impacts on yield begin to level off. As such, maintaining soil organic carbon content within a certain threshold (depending upon local context) is a key component to continued crop yields.[205]

The fertility of soils can also be negatively impacted by land management practices. For example, agricultural areas commonly use heavy machinery for cultivation, which can lead to **soil compaction**. Studies have shown that heavy agricultural equipment deployed in wet conditions can reduce long-term crop yields by 2.5-15%.[206] The overuse of

[203] Milder (2022) Environmental degradation: impacts on agricultural production.
[204] Panagos et al., (2018) Cost of agricultural productivity loss due to soil erosion in the European Union: From direct cost evaluation approaches to the use of macroeconomic models.
[205] Oldfield (2019) Global meta-analysis of the relationship between soil organic matter and crop yields.
[206] Voorhees (2000) Long-term effect of subsoil compaction on yield of maize. In: Horn et al., (Eds.), Subsoil Compaction: Distribution, Processes and Consequences; Bennetzen (2016) Soil compaction effects on crop yield (in Danish). In Pedersen, J.B.

nitrogen fertilisers has been shown to contribute to **acidification** in arable soils – increasing the concentration of toxic elements and restricting crop growth due to nutrient deficiency and toxicity within the soil.[207] **Soil sealing** is estimated at contributing to a loss of 0.81% of agricultural production in 19 EU countries between 1990 and 2006, the equivalent of 6 million tons of wheat. Although the overall percentage of agricultural production affected was small, areas near large cities in Central and Western Europe and coasts of Southern Europe were particularly affected, with some losing over 10% of their agricultural production potential.[208,209] **Salinisation,** which can also be caused by improper soil and water management, results in increased levels of dissolved sodium and chloride ions in soil. In sufficient concentrations, these can displace other mineral nutrients in the soil. Plants then absorb the chlorine and sodium instead of nutrients such as potassium and phosphorus leading to nutrient deficiencies, which in turn produce decreased biomass.[210] Furthermore, salinisation results in less soil organic carbon, which exacerbates soil erosion and further yield reductions.[211]

Finally, the loss of **soil biodiversity** has been identified as contributing to reduced crop yields. Rich, diverse soil communities can lead to increased storing capacity of soil organic matter – which in turn can increase soil organic carbon and ultimately increase crop yields.[212] Studies have shown that more than 75% of crops and 35% of food produced rely on pollination services,[213] which are provided not only by the likes of bees, but also pollinators which directly interact with soil such as beetles (*Carpophilus hemipterus L.* and *Carpophilus mutilates*) and thrips (*Thrips hawaiiensis* and *Haplothrips tenuipennis*).[214] Furthermore, the presence of earthworms has been reported, on average, to increase crop yields in 25% of agroecosystems,[215] underlying their importance in sustaining economically viable crop yields.

4.1.3 Reduced fertility of EU soils for forestry

The forested area in Europe has been largely stable over the last two decades, and it only expanded because of afforestation programmes in some European countries and through spontaneous regeneration on abandoned agricultural land. Changes in forest land cover are now locally concentrated in a few European countries. Despite the stable area, forest ecosystems are subject to pressures and changes in their condition, which raises concern over their long-term stability and health.[216]

As previously mentioned, some signs of an increasing limitation of **phosphorous** for the growth of trees and forest stands have been reported (e.g. Sardans et al., 2016).[217] In addition, the **erosion of forest soils** can affect forest productivity by decreasing soil

(Ed.), Oversigt over Landsforsøgene 2016. Report from The Danish Agriculture & Food Council; Brus and van den Akker (2017) How serious a problem is subsoil compaction in the Netherlands? A survey based on probability sampling; Stolte et al., (2016) Soil threats in Europe- Available at: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/doc_pub/EUR27607.pdf

[207] EEA (2022) Soil monitoring in Europe Indicators and thresholds for soil quality assessments. https://www.eea.europa.eu/publications/soil-monitoring-in-europe-indicators-and-thresholds

[208] Gardi et al., (2015) Land take and food security: assessment of land take on the agricultural production in Europe.

[209] Milder (2022) Environmental degradation: impacts on agricultural production.

[210] RECARE HUB (2018) Soil Threats- Salinisation- available at: https://www.recare-hub.eu/soil-threats/salinization

[211] RECARE HUB (2018) Soil Threats- Salinisation- available at: https://www.recare-hub.eu/soil-threats/salinization

[212] Bach et al., (2020) Soil Biodiversity Integrates Solutions for a Sustainable Future

[213] Apriyani et al., (2021) What evidence exists on the relationship between agricultural production and biodiversity in tropical rainforest areas? A systematic map protocol

[214] Klein et al., (2006) Importance of pollinators in changing landscapes for world crops

[215] Nielsen, Wall and Six (2015) Soil biodiversity and the environment

[216] EEA (2019) The European environment — state and outlook 2020

[217] EEA (2022) Forest dynamics in Europe and their ecological consequences. Available at: https://www.eea.europa.eu/publications/forest-dynamics-in-europe-and-1/forest-dynamics-in-europe-and

water availability, removes nutrients that plants need, degrade soil structure, and can result in loss of soil biota.[218]

4.1.4 Reduced water retention capacity

Soils have the capacity to retain and store significant quantities of water, which not only maintains freshwater stocks, but can enhance plant growth, mitigate flooding and prevent erosion.[219,220] For example, the cost of the devastating floods that occurred in Germany, Belgium and the Netherlands in 2021 was estimated to reach EUR 32 billion. While the exact contribution of soil degradation is not clear in these specific cases, studies have identified that the last 30 years of soil sealing alone, in the EU, have increased flood risk to the same effect as moderate climate change scenarios. Indeed, soil degradation is leading to a steady decrease of the water retention capacity of the soil (see figure on the soil moisture indicator – source EEA). Yet the "sponge" capacity of the soil is of outmost important for combatting the effects of droughts and floods. Combatting the soil moisture deficit can make a very strong contribution to the EU water scarcity and water resilience agenda.

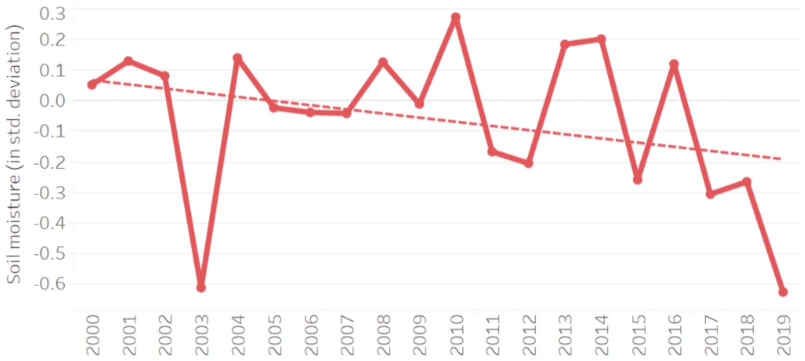

Figure 4-1 Long-term average soil moisture indicator by year (2002-2019), EEA

Available at: https://www.eea.europa.eu/data-and-maps/data/data-viewers/soil-moisture

Soils with high water capacity available for flora have also been found to increased resilience to rainfall changes,[221] which can alleviate climate change impacts. However, projected mean temperature increases in Europe are estimated to increase total soil moisture drought area by up to 40%, [222] which will ultimately negatively impact the water regulating services of soil. This is expected to be more prevalent in Southern and Central European regions,[223] yet 1.45 million km^2 of EEA-38 + UK land mass was impacted by soil moisture deficits in 2019.[224]

The main factors which can impact the water retention capacity of soils include soil organic carbon and texture, which can in turn be modified by soil erosion, compaction, soil management practices and sealing. Each are discussed in turn below, but it is worth considering that many soil functions and processes are driven by **soil biodiversity,** whose interactions directly affect soil ecosystem services – including water retention

[218] Elliot et al. The Effects of Forest Management on Erosion and Soil Productivity. Available at: https://forest.moscowfsl.wsu.edu/smp/docs/docs/Elliot_1-57444-100-0.html
[219] Dominati et al., (2010) A framework for classifying and quantifying the natural capital and ecosystem services of soils.
[220] Wall et al., (2020) A Decision Support Model for Assessing the Water Regulation and Purification Potential of Agricultural Soils Across Europe
[221] Wall et al., (2020) A Decision Support Model for Assessing the Water Regulation and Purification Potential of Agricultural Soils Across Europe
[222] Samaniego et al., (2018) Anthropogenic warming exacerbates European soil moisture droughts.
[223] Cammalleri et al., (2016) Recent temporal trend in modelled soil water deficit over Europe driven by meteorological observations.
[224] EEA (2021) Soil moisture deficit. Available at: https://www.eea.europa.eu/ims/soil-moisture-deficit

capacity. Soils with diverse biota can enhance the overall soil structure, which promotes water infiltration and holding capacity.[225]

Soil erosion reduces the water retention capacity, by a volume effect (less soil is available for storing water), but also due to a degradation of the soil features supporting water retention in the remaining soils.[226] As mentioned in the previous sections, erosion can lead to a loss of organic matter and carbon content of soils. The effect of carbon loss on water retention capacity is dependent on the texture of the soil, and the baseline carbon content. Coarse soils with low initial carbon contents show that increases to carbon content leads to an increase in water retention capacity, yet in finer-textured soils an inverse relation occurs. At high carbon content, an increase in carbon results in an increase in the water retention capacity of all soil textures.[227] As a result, loss of SOC is linked to higher risks of desertification, resilience to droughts and mitigation of flood peaks.

Regarding **soil compaction**, studies (on arable soils) have demonstrated that increased soil bulk density (modelled at a 10-20% increase due to compaction by heavy machinery) led to a reduction in water infiltration (55-82%), and a decreased water storage capacity (3-49%), dependent on soil type.[228] This can lead to the exacerbation of drought and water logging of soils, which are likely to be intensified due to variable precipitation regimes due to climate change.[229]

Soil management practices can impact the water retention capacity of soils, yet the impacts are dependent on inter alia, soil structure and type, land cover type, and climatic conditions. Management practices such as organic farming practices have been shown to increase water retention through increased soil aggregation and improved soil structure,[230] but in other instances, conventional farming practices have been highlighted as to hold greater quantities of water due to higher microporosity.[231] Similarly, reduced/no-tillage practices (vs conventional tillage) have been shown in some instances to impact water retention capabilities of soils, but results are varied and dependent on soil profiles.[232] Furthermore, the addition of organic material to soils is commonly associated with increased SOC, which in turn impacts the water retention capacity of soils. Ultimately, the absolute levels of SOC in soils, impacted by management practices, has varying impacts of the retention capacity of soils depending on their structure/texture (i.e. sandy soils vs clay soils).[233]

Finally, **soil sealing** can lead to the significant reduction of water infiltration and retention. The latest data indicates that over 77,000 km^2 (1.77% of total terrestrial area) of sealing has occurred in terrestrial land in the EU-28.[234] The most obvious immediate impact is the loss of available fertile land which could be utilised for other purposes such

[225] Nielsen et al., (2015) Soil Biodiversity and the Environment
[226] Li et al., (2021) Soil erosion leads to degradation of hydraulic properties in the agricultural region of Northeast China
[227] Rawls et al., (2003) , Effect of soil organic carbon on soil water retention
[228] Ngo-Cong et al., (2021) A modeling framework to quantify the effects of compaction on soil water retention and infiltration
[229] Hartmann et al., (2012) Effect of compaction, tillage and climate change on soil water balance of Arable Luvisols in Northwest Germany.
[230] Williams et al., (2017) Organic Farming and Soil Physical Properties: An Assessment after 40 Years
[231] Panagea et al., (2021) Soil Water Retention as Affected by Management Induced Changes of Soil Organic Carbon: Analysis of Long-Term Experiments in Europe
[232] Panagea et al., (2021) Soil Water Retention as Affected by Management Induced Changes of Soil Organic Carbon: Analysis of Long-Term Experiments in Europe
[233] Panagea et al., (2021) Soil Water Retention as Affected by Management Induced Changes of Soil Organic Carbon: Analysis of Long-Term Experiments in Europe
[234] EEA (2019) Imperviousness in Europe. Available at: https://www.eea.europa.eu/data-and-maps/dashboards/imperviousness-in-europe

as agriculture, thus providing additional ecosystems services. However, more fundamentally, sealing damages/destroys the relationship between soil and the biosphere, atmosphere and hydrosphere which can ultimately significantly impact the capability of soil to transmit/retain water and gas.[235] In turn, sealed areas can increase water runoff and flood risk, impact groundwater replenishment, negatively impact biodiversity, and impact carbon sequestration.

4.1.5 Reduced water filtering capacity

Soils, sediments and water are intimately connected. Soils filter, absorb and buffer water, through fixating and the retention of solutes. When water passes through soil, contaminants are removed through a series of physical, chemical and biological processes. In addition to soil's physical filtration capacity, soil organisms transform and decompose certain chemicals and other contaminants from soil, thus remove them from water. Thus, through the various forms of soil degradation outlined below, the ability and capacity of soils to filter water can be greatly impacted.

Soil erosion can negatively impact the water filtration and percolation capacity of soils, through the removal of habitat space[236]. This can lead not only to reduced crop yields,[237] but also lead to the release of contaminants and/or excess nutrients into water bodies.[238]

The **contamination of soils** (as noted in section 2.2.2, up to 2.8 million contaminated sites exist in the EU) can negatively impact the filtering capacity of soils. Depending upon the contaminant type and concentration, soil pollution can reduce the capacity of soils to filter and buffer – which can ultimately negatively impact ecosystems and consequently human health.[239] This also applies to the excessive application of nutrients, as outlined in the sections above, whereby such usage can lead to soil acidification (and decline of soil organic matter) and decreased retention of soil sorption potential.[240]

The **reduction of SOC** can lead to decreased filtration and biodegradation capabilities of soils.[241] More specifically, it was found that a loss of SOC reduces the capacity to filter organic pesticides, unless the soils were already degraded enough to display hydrophobicity.[242] The increased prevalence pesticide concentrations in soils can negatively impact soil biodiversity (namely invertebrates),[243] and thus all soil ecosystem services. In relation to plant biodiversity, a meta-analysis of studies on the effects highlighted the impacts of plants on the removal of chemicals from water – whereby "*a positive effect on chemical oxygen demand and total nitrogen removal, and a marginal effect on phosphorus removal*", even if "*no significant effect* of *plant richness on removal of total suspended solids*" was identified. [244]

Finally, **soil sealing** can result in total loss of soil ecosystem services and functioning- including the capability to filter water. Furthermore, soil sealing can result in increased

[235] Virto et al., (2015). Soil degradation and soil quality in Western Europe: current situation and future perspectives.
[236] Gregory et al., (2015) A review of the impacts of degradation threats on soil properties in the UK
[237] Ferreira et al., (2022) Soil degradation in the European Mediterranean region: Processes, status and consequences
[238] IUNG (2019) The impact of soil degradation on human health. Institute of Soil Science and Plant Cultivation
[239] Ferreira et al., (2022) Soil degradation in the European Mediterranean region: Processes, status and consequences
[240] Makovnikova and Barancikova (2012) Acidification and loss of organic matter in the context with soil filtration function
[241] Ferreira et al., (2022) Soil degradation in the European Mediterranean region: Processes, status and consequences
[242] Aslam et al., (2009) Does an increase in soil organic carbon improve the filtering capacity of aggregated soils for organic pesticides? — A case study
[243] Gunstone et al., (2021) Pesticides and Soil Invertebrates: A Hazard Assessment
[244] Brisson et al., (2020) Plant diversity effect on water quality in wetlands: a meta-analysis based on experimental systems

pollutant runoff entering the environment,[245] however the precise correlation between these cannot be distinguished.

4.1.6 Reduced carbon sequestration capacity

Soils play an integral role in the combat against climate change through their role as a carbon sink.[246] The sequestration potential and carbon content of soil can be affected by anthropogenic factors, notably land use changes, soil management, and (associated) soil degradation.

Although available evidence suggests that the LULUCF sector annually stores more carbon than they emit,[247] EU soils are net emitters even though they are expected to act as carbon sinks and significantly contribute to carbon removal in the future. This expectation is put forward in the EU Soil Strategy, which states that net removals from LULUCF sector were reduced by 20% between 2013 and 2018 in the EU. Indeed, the declining forest sink has increased the expectation on European soils to make up for the difference in meeting the overall carbon removal target of 500–600 $MtCO_2eq$/yr. Assuming no further decline in the forest sink, EU soils would be expected to store up to 260 $MtCO_2$/yr[248] Considering current trends, significant changes are needed to achieve this objective as croplands are still currently losing carbon. As an example, the EU-27+UK is estimated to have lost 4.2 million tonnes of carbon sequestration potential through sealing between 2012-2018.[249]

Agricultural and land management practices can have a positive or negative effect on soil carbon content.[250] Notably, a widespread adoption of carbon-friendly land management practices (i.e., peatland restoration, agroforestry, substituting maize with grass, increased use of cover crops, leaving crop residues on the soil surface, etc.) could remove an additional 150–350 $MtCO_2$/yr across the EU (amounting to 6.3-14.7% of net EU-27 CO_2 emissions in 2020).[251] Moreover, an additional storage of 250–350 $MtCO_2$/yr could be obtained from land-use changes (amounting to 10.49-14.7% of net EU-27 CO_2 emissions in 2020).[252] This means that the adoption of such practices across the EU may be sufficient to achieve the 260 $MtCO_2$/yr storage need.

The loss of carbon sink potential can have significant, negative impacts on climate change. For example, in 2019, a loss of carbon from 17.8 Mha of organic soils was calculated at emitting 108 $MtCO_2$ due to the cultivation and drainage practices.[253] Furthermore, soil organic carbon content can limit soil's ability to provide nutrients for sustainable plant production, lowering crop yields (affecting food security, see section

[245] Vanderhaegen et al., (2015) High resolution modelling and forecasting of soil sealing density at the regional scale
[246] EEA (2019) The European environment — state and outlook 2020
[247] EEA (n.d.) Climate and energy in the EU. Available at: https://climate-energy.eea.europa.eu/topics/climate-change-mitigation/land-and-forests/intro
[248] https://www.nature.com/articles/s41558-022-01321-9.epdf?sharing_token=SJNOrE39rIOgYQQP_NJY9NRgN0jAjWel9jnR3ZoTv0Owkj7L-J-zdNOT_oKPVzSI203Dd0s-Eae1bBy6eqWbzL-fUGfL41CRLWkZMn5FTUkBmni2HamE7B2TUWfqYWa895bSKw7jfYhy9ZPRZ3ICaZGMnoxN16TMtby3SnWMhiY%3D
[249] EEA (2022) Impact of soil sealing in Functional Urban Areas, 2012-2018. Available at: https://www.eea.europa.eu/data-and-maps/data/data-viewers/impact-of-soil-sealing-in
[250] CLIMSOIL (2008) Review of existing information on the interrelations between soil and climate change.
[251] EU27 CO2 net emissions reached 2,383 million tonnes CO2 in 2020 according to data published by the EEA.
[252] https://www.nature.com/articles/s41558-022-01321-9.epdf?sharing_token=SJNOrE39rIOgYQQP_NJY9NRgN0jAjWel9jnR3ZoTv0Owkj7L-J-zdNOT_oKPVzSI203Dd0s-Eae1bBy6eqWbzL-fUGfL41CRLWkZMn5FTUkBmni2HamE7B2TUWfqYWa895bSKw7jfYhy9ZPRZ3ICaZGMnoxN16TMtby3SnWMhiY%3D
[253] EEA (2022) Soil Carbon. Available at: https://www.eea.europa.eu/publications/soil-carbon

2.4.2) and decreasing food availability for soil organisms (reducing soil biodiversity). The aforementioned loss of soil water infiltration capabilities due to carbon loss can leading to increased run-off and erosion, which in turn may even lead to desertification.[254]

4.2 (second order) Consequences on economy and society

The degradation of ecosystem services provided by soils have tangible impacts the economy and society as a whole. These impacts on economy and society have been classified as 'second-order impacts'. These second-order impacts are often transboundary and require legislative action at the scale of the EU. The below thus sections identify and address these second-order consequences, in order to justify EU-level action.

4.2.1 Transboundary transport of soil by water

Soil erosion is directly connected to two broad, over-arching environmental impacts: on-site soil loss and off-site impacts. Erosion of soils impact the all biochemical cycles,[255] soil productivity,[256] water quality (and associated flora and fauna),[257] and increase sediment loads which can obstruct waterways and floodplains.[258] Of the approximately 100 transboundary river basins in the EU, 25% have identified soil erosion issues (due to agricultural practices).[259] In the Rhine River alone, it is estimated that approximately 117 million tonnes of sediment are transported each year, which can cause significant downstream issues in the event of contaminated sediments (treatment/disposal costs), increased costs of sediment dredging, increased flooding (magnitude and frequency), and loss of recreational functions (due to lower water quality).[260]

The transport of soils by water can cause transboundary issues as contaminated soils can be deposited downstream following erosion, and hence transport pollutants from a source in one Member States to recipients in another. Furthermore, nutrient overuse can incur a range of negative, transboundary environmental impacts which impact not only soil, but waterways, air, biodiversity, human health and climate change. Economic impacts of eutrophication are challenging to analyse, due to the locality of their occurrence and the ability to monitor and correlate eutrophication events directly to economic impacts. Furthermore, the loss of biodiversity in local areas can have global (economic) impacts, through, for example, the loss of genetic resources or knowledge transfer. Conservative estimates of annual costs of eutrophication have indicated USD 1 billion losses for European coastal waters.[261] It is estimated in the EU that the application of fertilisers is on average 31% higher than environmental thresholds,[262] and 62% of the European

[254] JRC (2009) Organic matter decline. Available here: https://esdac.jrc.ec.europa.eu/projects/SOCO/FactSheets/ENFactSheet-03.pdf
[255] Borelli et al., (2018) A step towards a holistic assessment of soil degradation in Europe: Coupling on-site erosion with sediment transfer and carbon fluxes
[256] EC (2021) Questions and Answers on the EU Soil Strategy. Available at: https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_5917
[257] SedNet (2004) Contaminated Sediments in European River Basins
[258] Maaß et al., (2021) Human impact on fluvial systems in Europe with special regard to today's river restorations.
[259] Álvaro-Fuentes et al., (2019) Drivers and transboundary impacts of soil degradation
[260] Álvaro-Fuentes et al., (2019) Drivers and transboundary impacts of soil degradation
[261] Wurtsbaugh et al., (2019). Nutrients, eutrophication and harmful algal blooms along the freshwater to marine continuum.
[262] https://www.sciencedirect.com/science/article/pii/S0048969721023548

ecosystem area is threatened by the negative impacts associated with eutrophication due to the exceedance of the critical loads.[263]

Regarding economic impacts of soil loss, Panagos et al. (2022)[264] estimated that current phosphorus displacement in the EU-27+UK was approximately 97,000 t annually in river basins and sea outlets. Applying an average cost of DAP phosphate (the common application of phosphate to soils) of EUR 1000 per tonne, it is estimated that the cost of phosphate loss in agricultural soils due to (wind and water erosion) costs the EU-27+UK between EUR 1.12-4.3 billion annually (accounting for the total phosphate content of 1 tonne of DAP phosphate – approximately 20%).

4.2.2 Transboundary transport of soil by wind

The impacts of soil loss due to wind can also endure far beyond the site of the erosion, as wind borne soil particles can transport pollutants causing contamination and impacting air and water quality and by consequence human health.[265,266,267] This can be illustrated by a Canadian example, where wind erosion is one of the major forms of soil degradation on the Canadian prairies. Particulate matter emanating from agricultural soil (e.g. pesticide residue trifluarin) can be transported long distances in the atmosphere and, if the soil has significant clay content, would contain particles less than 2 µm in diameter. Particles of this size range have been associated with respiratory health effects in humans and if they have pesticides associated with them the risk of health effects may be increased.[268] This can be further shown by an example in Australia, where wind erosion in arid inland Australia leads to dust plumes, which can pass overpopulated coastal areas in Eastern Australia. Such events can lead to concerns about respiratory health problems because they significantly increase the fine particle component of atmospheric aerosols. Research shows that number of these dust events were significantly associated with changes in asthma severity.[269]

Sediments removal and cross boarder effect.
JRC estimates that soil loss from Europe in the riverine systems is about 15% of the estimated gross on-site erosion. The estimated sediment yield totals about 165 million tonnes ending in river basins and sea outlets. JRC has done a meta-analysis collecting information from local studies (Italy, Luxembourg, Germany, France, and Netherlands) on sediments removal costs and the average price is 15-20 EUR/m^3 and 5-10 EUR/m^3 for transfer the sediments elsewhere. Therefore, a grosso-modo estimation of removing the 75 million m^3 is about EUR 1.5-2.3 billion per year. Those estimates are done using the method of dry excavation and removal to landfill.

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[263] FAO (2018) Proceedings of the Global Symposium on Soil Pollution 2018. Rome, Italy, Food and Agriculture Organization of the United Nations
[264] Panagos et al., (2022) Improving the phosphorus budget of European agricultural soils
[265] Lackoova et al., (2021) Long-Term Impact of Wind Erosion on the Particle Size Distribution of Soils in the Eastern Part of the European Union
[266] Borelli et al., (2017) A New Assessment of Soil Loss Due to Wind Erosion in European Agricultural Soils Using a Quantitative Spatially Distributed Modelling Approach
[267] Stolte et al., (2016) Soil threats in Europe.
Available at: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/doc_pub/EUR27607.pdf
[268] https://cdnsciencepub.com/doi/10.4141/S04-075
[269] https://link.springer.com/article/10.1007/s004840050108

4.2.3 Mitigation of climate change

In the short term, the GHG emissions from soils, estimated at 41 Mtonnes CO_2eq/yr can be estimated, based on a price per tonne of CO_2eq of EUR 90,[270] to have a cost of EUR 3.7 billion. As demonstrated in the section above, the EU27+UK is estimated to have lost 4.2 million tonnes of carbon sequestration potential through sealing between 2012-2018. This alone (not accounting for other changes in land use/management), when applying a price per tonne of CO_2eq of EUR 90 EUR,[271] equates to a societal cost of EUR 378 million in this time period. When considering the potential carbon sequestration rates presented in the section above from carbon farming practices (150-350 MtCO_2/yr) and land use changes (250–350 MtCO_2/yr) and applying the same CO_2eq of EUR 90, it is estimated that cost savings range between EUR 36-63 billion per year.

In the long-term, the impacts of climate degradation on human societies and economies have recently been updated by the IPCC report on 'Impacts, adaptation and vulnerability'.[272] A key finding of this report is that:

> *TS.C.3 Climate change will increasingly add pressure on food production systems, undermining food security (high confidence). With every increment of warming, exposure to climate hazards will grow substantially (high confidence), and adverse impacts on all food sectors will become prevalent, further stressing food security (high confidence). Regional disparity in risks to food security will grow with warming levels, increasing poverty traps, particularly in regions characterised by a high level of human vulnerability (high confidence).*

The consequences of food shortages on the stability of societies have historically been very severe, and can lead to major social unrest, armed conflicts or mass migration, with considerable attached costs.

4.2.4 Adaptation to climate change

As outlined in the sections above, healthy, functioning soils produce a range of ecosystem services- many of which can act as powerful defences against climate change impacts. For example, healthy soils can absorb greater volumes of water than degraded soils, relieving downstream areas from the impacts of excessive precipitation events and subsequent flooding. In 2021 alone, flooding events were calculated at causing EUR 38 billion in economic losses.[273]

Soil sealing makes previously permeable, water retaining surfaces, impermeable- preventing water to infiltrate the soil substrate and increasing the proportion of rapid surface runoff which accrues downstream.[274] Studies have identified that the impact of the last 30 years of soil sealing in the EU have increased flood risk to the same effect as moderate climate change scenarios (i.e. the RCP 4.5 scenario). Ultimately, it is estimated that the continued rate of urban development and soil sealing could lead to an increase in

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270 https://tradingeconomics.com/commodity/carbon
271 https://tradingeconomics.com/commodity/carbon
272 International Panel on Climate Change – IPCC (2022) WGII Sixth Assessment Report
273 AON (2022) 2021 Weather, Climate and Catastrophe Insight. US $46billion calculated as €37.59 billion.
274 Gabriels et al., (2021) A comparative flood damage and risk impact assessment of land use changes

areas at higher risks of flooding corresponding to 1-2% of total urban areas (when coupled with projected climate change scenarios).[275]

Furthermore, healthy soils can release water at a slower rate during drought conditions- mitigating the impacts felt to economic activities including agriculture, energy and water sectors. Such activities incur approximately EUR 9 billion economic losses per year in the EU-27+UK due to droughts.[276]

4.2.5 Food security, quality and nutritional value

Soil provides the base on which crops can grow, as well as nutrient and water essential for their growth. The paramount importance of soil for food security makes its degradation – which affects 61% to 73% of agricultural soils in the EU.[277] This section will discuss consequences of soil degradation on the capacity to produce food, its quality, and nutritional value. In addition, the heavy metals concentration in topsoils has a transboundary effect in the produced food and feed.

IPBES Report from 2018 estimated that land degradation globally negatively impacts 3.2 billion people and represents an economic loss in the order of 10% of annual global gross product. Nevertheless, seeking to act in the face of land degradation and also restoring land makes economic sense. Studies from Asia and Africa indicate that the cost of inaction regarding land degradation is at least three times higher than the cost of action. Moreover, the benefits of restoration can be 10 times higher than the costs, which was estimated across nine different biomes.[278] In Europe specifically, Panagos et al. (2018) estimated that the annual cost of soil erosion in agricultural productivity amounts to around EUR 1.25 billion.

In a recent report (2021) on soil degradation and the true price of agri-food products,[279] a broader attempt for quantification has been made. This study highlights three indicators of soil degradation: soil erosion (wind and water), SOC loss and soil compaction. The monetisation approach for soil erosion that was used were the damage costs. Here, the focus was especially on the on-site components of soil erosion which include: loss of nutrients, reduced harvests and reduced value of land and the off-site components of soil erosion which include: silting up of waterways, flooding and repairing public and private property. Taking all these factors into account, that study set the estimated global value of soil erosion from water was at 0.0214 EUR/kg soil loss and the estimated global value of soil erosion from wind was set at 0.0273 EUR/kg soil loss. SOC loss was monetised by looking at the marginal damage cost based on future crop yield loss and the global average was found to be 0.0300 EUR/kg SOC loss. Lastly, soil compaction was monetised using the damage cost on lost future crop yields. Flooding, water pollution and increased GHG emissions were not included in this monetisation, as they are very hard to estimate.[280] The global average for soil compaction was estimated to be 0.5518

[275] Kaspersen et al., (2017). Comparison of the impacts of urban development and climate change on exposing European cities to pluvial flooding.
[276] EC (2020) Impacts of climate change on droughts. Available at: https://joint-research-centre.ec.europa.eu/system/files/2020-09/07_pesetaiv_droughts_sc_august2020_en.pdf
[277] IEEP (2022) Environmental degradation: impacts on agricultural production. Available at: https://ieep.eu/uploads/articles/attachments/548d9fc9-3f2e-4fa6-9dbe-a51176b5128c/Policy%20brief_Environmental%20degradation.%20Impacts%20on%20agricultural%20production_IEEP%20(2022).pdf?v=63816541685
[278] https://zenodo.org/record/3237411#.Y34_AHbMI2w
[279] https://edepot.wur.nl/557712
[280] https://edepot.wur.nl/557712

EUR/tonne-km,[281] these values were significantly higher for countries with high yields of crop production such as the Netherlands.

Food production and security

The impacts that soil threats have on food production are documented to varying extents. The 12 million hectares of agricultural areas in the EU that suffer from severe erosion are estimated to lose around 0.43% of their crop productivity annually, leading to an estimated annual loss of EUR 1.25 billion.[282] As shown in **Error! Reference source not found.**, losses in terms of crop productivity and associated monetary losses vary per crop, but all crops presented in the study face losses due to erosion reaching several million EUR annually. Using macroeconomic modelling, the same study finds that the losses in agricultural production due to soil erosion in the EU translates into an annual loss of EUR 295.7 million to the agricultural sector.[283] The scale of impacts varies per MS, with Italy suffering the highest impacts (change in agricultural production of -0.75%, amounting to -251.328 million EUR), followed by Spain (change in agricultural production of -0.20%, amounting to -60.854 million EUR). On the other hand, most Northern and Central European countries are only marginally affected by soil erosion losses.[284,285]

Table 4-1: Estimated annual productivity loss per crop due to erosion, using direct cost evaluation (year 2010). Source: Panagos et al. (2018)[286]

Crop	Total area (1,000 ha)	Actual productivity (1,000 t)	Area severely eroded (1,000 ha)	Crop productivity loss in affected areas (1,000 t)	% of tonnes lost	Price (€/t)	Crop productivity loss (million €)
Maize	15,703.0	111,586	1,124.0	594.4	0.53	220.8	131.222
Barley	24,975.6	110,072	1,152.1	307.6	0.28	221.7	68.199
Rape, turnip rape, and soya	22,786.0	135,877	789.3	380.1	0.28	479.2	182.154
Sunflower seed	4,285.9	6,956	313.7	37.2	0.53	449.1	16.712
Potatoes	1,797.5	55,271	78.0	143.2	0.26	299.1	42.841
Sugar beets	1,661.0	116,017	50.4	327.2	0.28	43.6	14.265
Rye	2,500.3	9,082	66.6	15.9	0.18	200.5	3.202
Rice	894.0	6,091	191.4	104.6	1.72	362.1	37.883
Pulses	2,036.1	5,243	152.7	29.6	0.57	734.9	21.779
Wheat (all types)	90,647.9	422,883	8,141.3	3,037.7	0.72	243.4	739.365
Total	167,287.3		12,059.6				1,257.622

Conversely, impacts from others soil degradations to food security remain relatively less known due to lack of data, for instance due to acidification, salinisation, losses of soil biodiversity or declines in soil organic matter.[287]

[281] This unit of measurement is used to as a proxy for the cumulated pressure on the soil caused by the machinery, which is the main cause of soil compaction, during one growing cycle on 1 ha.

[282] P. Panagos et al. (2018) Cost of agricultural productivity loss due to soil erosion in the European Union: From direct cost evaluation approaches to the use of macroeconomic models available at https://onlinelibrary.wiley.com/doi/full/10.1002/ldr.2879

[283] This amount is smaller than the total amount of loss in crop productivity due to a partial substitution of the less productive land in the agricultural production process with more labour and capital input, and to an increase in competitiveness for countries with less losses from soil erosion, therefore leading to greater demand and production.

[284] In some MS, agricultural production is expected to increase, and so is the financial impact on the agricultural sector as a result. According to the study, this increase is due to the effect of trade mechanisms, with countries for which the decline in land productivity is lower expected to become more competitive (i.e., the price of their agricultural commodities increases less than that of their competitors), therefore experiencing greater demand and production.

[285] Panagos et al., (2016) Cost of agricultural productivity loss due to soil erosion in theEuropean Union: From direct cost evaluation approaches to theuse of macroeconomic models.

[286] Panagos et al., (2016) Cost of agricultural productivity loss due to soil erosion in theEuropean Union: From direct cost evaluation approaches to theuse of macroeconomic models.

[287] IEEP (2022) Environmental degradation: impacts on agricultural production. Available at: https://ieep.eu/uploads/articles/attachments/548d9fc9-3f2e-4fa6-9dbe-

Few studies have quantitatively investigated the effects of soil compaction on yields. It is estimated that soil compaction has led to 2.5-15% crop yield reductions. Applying this to the economic output of EU-27 crops (estimated at EUR 248 billion in 2021),[288] the economic impacts of soil compaction on loss of crop yields are estimated at EUR 6.2-37.2 billion annually in the EU-27.

Via the expansion of urban areas (land take), fertile agricultural land can be used to build new residential, commercial or industrial areas (see section 2.1.2 above). This practice is problematic in view of the importance of soils for ensuring European food security. Notably, municipalities can be tempted to maximise their local revenues by reallocating agricultural land to urban development.[289] One study estimated the loss of potential agricultural production following soil sealing in 19 EU countries to be around -6 million tons of wheat between 1990 and 2006. While this loss amounts only to -0.81% of potential agricultural production over this period, areas near large cities in Central and Western Europe and coasts of Southern Europe were particularly affected, some of them losing more than 10% of their agricultural production potential.[290,291]

Food quality and nutritional value

It is generally accepted that organic and agroecological farming practices can promote and support more active soil biology (a key determinant of soil health), and therefore increase nutrient cycling, compared to conventional farming.[292] However, the nutritional value of crops is also dependent on climate conditions, soil types, and crop variety itself – which all result in difficulty assessing the specific impact of soil health on food quality/nutritional value from the two aforementioned management practices. Nonetheless, meta-analyses by Worthington (2001),[293] Lairon (2010),[294] Hunter (2011)[295] and Baranski et al. (2014)[296] found that organically produced products had greater vitamin, iron, magnesium, antioxidants, copper and zinc levels. Furthermore, another generally agreed upon aspect is that pesticide residues are higher in conventional farming, which has implications on human health.

4.2.6 Human health

Many of the issues discussed in the previous sub-chapters can lead to direct, negative impacts on human health. **Erosion** can lead to greater airborne particulate matter, causing respiratory and cardiovascular diseases,[297] whilst indirectly causing health issues from

a51176b5128c/Policy%20brief_Environmental%20degradation.%20Impacts%20on%20agricultural%20production_IEEP%20(2022).pdf?v=63816541685

[288]From https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Performance_of_the_agricultural_sector#Value_of_agricultural_output – whereby total economic output of the agricultural industry is calculated at €449.5 billion, 55.3% from crop production

[289] https://ec.europa.eu/environment/soil/pdf/guidelines/pub/soil_en.pdf

[290] Gardi et al., (2014) Land take and food security: assessment of land take on the agricultural production in Europe

[291] IEEP (2022) Environmental degradation: impacts on agricultural production.

[292] Nowak et. Al (2013) To what extent does organic farming rely on nutrient inflows from conventional farming? available at https://iopscience.iop.org/article/10.1088/1748-9326/8/4/044045#erl486747s4

[293] Worthington (2001) Nutritional quality of organic versus conventional fruits, vegetables and grains.

[294] Lairon (2010) Nutritional quality and safety of organic food: a review.

[295] Hunter et al., (2011) Evaluation of the micronutrient composition of plant foods produced by organic and conventional agricultural methods.

[296] Baranski et al., (2014) Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses.

[297] Goudie (2014) Desert dust and human health disorders ; Stafoggia et al., (2016) Desert dust outbreaks in Southern Europe: Contribution to daily OM10 concentrations and short-term associations with mortality and hospital admissions..

the degradation of water quality. **Soil sealing** can negatively impact human health through prolonging the duration of high temperatures (particularly during heat waves), reducing the capacity of soils to act as a sink for pollutants (thus contributing to air pollution), and increased impact on water runoffs (leading to additional flood risk).[298]

The **contamination of soils** through pollutant activities, such as industry, inadequate waste management, or unbalanced chemical management in agricultural lands, can affect food safety and human health, depending on soil properties and soil functions.[299] Approximately 21% of agricultural soils in the EU contain cadmium concentrations in the topsoil which exceed the limit for groundwater, 1.0 mg/m^3 (used for drinking water).[300] While some metals are essential for plant growth and for humans (e.g., copper, iron, zinc and other macro- and micro-nutrients), high metal concentrations can induce toxicity for plants and expose the human population to disease problems. The intake of chemicals can occur via ingestion of contaminated soil, or via plant uptake, then passed on to humans via the food chain. High concentrations of heavy metals in the body can affect several systems including the blood, liver, brain, kidneys, and lungs, and long-term exposure to even low levels of heavy metals can result in neurological and physical degenerative processes (e.g., Parkinson disease and Alzheimer disease) and cancer.[301] Regarding pesticides, a study analysing residues in soils from 11 EU MS found that over 80% of these soils contained pesticide residues, glyphosate and its metabolites, as well as some broad-spectrum fungicides, the latter being the most frequently present pesticides and at the highest concentrations (up to 2.87 mg/kg).[302] As documented with agricultural workers, pesticides used in agricultural fields are associated with an increased risk of developing several chronic diseases, for instance diabetes, cancer, and asthma, as well as a variety of short-term problems (e.g., dizziness, nausea, skin and eye irritation, and headaches).[303] Here, the impact on health is not caused by pesticides being absorbed by the soil, but by pesticides being applied to soils. Microplastics found in soils, largely through the use of plastic mulch, sewage sludge, (encapsulated) fertilisers and atmospheric deposition, can enter the food chain and cause health problems due to (inter alia) their toxicity and incur changes to metabolism.[304]

4.2.7 Supply of woody biomass

Forest cover can contribute to preserving soil health through the provision of continuous vegetative cover. However, soil degradation can also occur in forested areas. Some evidence exists on the impacts of certain pressures (e.g. acidification, various forest management practices such as clear felling or the use of heavy machinery, climate change, wildfires) on the health of forest soil. In turn, the degradation of forest soils health has an impact on their yields.

The **compaction** of forest soils by heavy logging machinery is generally recognised as having a negative impact on the long-term yield of trees,[305] even if the evidence is difficult to gather because of the long time frames involved and the capacity of trees to

[298] IUNG (2019) The impact of soil degradation on human health.
[299] https://www.eea.europa.eu/soer/publications/soer-2020 (2019) The European environment — state and outlook 2020.
[300] EEA (2019) The European environment — state and outlook 2020.
301 Brevik et al., (2020) Soil and Human Health: Current Status and Future Needs
302 Silva et al., (2019) Pesticide residues in European agricultural soils – A hidden reality unfolded
[303] Brevik et al., (2020) Soil and Human Health: Current Status and Future Needs
[304] Sun et al., (2022) Health risk analysis of microplastics in soil in the 21st century: A scientometrics review
[305] Martina Cambi, Giacomo Certini, Francesco Neri, Enrico Marchi, "The impact of heavy traffic on forest soils: A review", Forest Ecology and Management, Volume 338, 2015, Pages 124-138, ISSN 0378-1127, https://doi.org/10.1016/j.foreco.2014.11.022

adapt to unfavourable environments.[306] A meta-analysis identified that soil compaction in forests, through the negative impacts it can (inter alia) cause to root systems and damage the porosity of soil, is estimated at causing direct economic damage to timber products and decreasing timber prices by up to 20%.[307]

The **acidification** of forest soils was reported to lead to the loss of an economically and ecologically high-value species, sugar maple, who are not able to regenerate after felling. The incurred economic loss was modelled at USD 214,000/ha.[308]

These yield losses in forests are important, because of the current and future contribution of forestry to the EU economy, with increased contribution of renewable resources. Considering the economic importance of woody biomass for several economic sectors (notably in rural areas) as well as the prominent role that forestry will play in the foreseeable future in the context of the bioeconomy, the preservation of soil health in EU forest areas is of paramount importance. As reported in the EU Forest Strategy,[309] as of 2018, 2.1 million people[310] were working in the traditional forest-based sector in the EU (forest management, logging, sawmilling, wood-based products, cork, pulp and paper), generating a gross value added of EUR 109,855 million. Another 1.2 million people worked in manufacturing of wood-based furniture and in printing on paper (e.g., books and newspapers), generating respectively EUR 25 and 31 billion gross added value.[311] The sector has grown in the past decade, with roundwood removals having increased by 14.8% between 2011-2020 in the EU-27, reaching 488,602.57 thousand cubic meters in 2020.[312] Moreover, removals are expected to further increase in the context of the bioeconomy, with a recent modelling study estimating that there will be a 40-70% gap in available supply compared to expected demand for biomass, with the largest share of this demand to be supplied via forestry.[313]

Several forest soil characteristics such as soil structure, moisture and nutrient status nonetheless do affect the biodiversity and ecological condition of forests and of forest soils, and therefore the availability of related products for humans.[314,315] As stated in the EU Forest Strategy to 2030: "*For trees to thrive, tree roots need to obtain all essential elements and nutrients from the soil. Therefore, the soil properties and soil ecosystem services must be protected as the very foundation of healthy and productive forests.*"[316]

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306 Miller RE, Colbert SR, Morris LA. Effects of heavy equipment on physical properties of soils and on long-term productivity: a review of literature and current research. Research Triangle Park (NC): National Council for Air and Stream Improvement, Inc. (NCASI); 2004. Technical Bulletin No. 887

307 Nazari et al., (2021). Impacts of logging-associated compaction on forest soils: A Meta-Analysis.

308 Jesse Caputo, Colin M. Beier, Timothy J. Sullivan, Gregory B. Lawrence, "Modeled effects of soil acidification on long-term ecological and economic outcomes for managed forests in the Adirondack region (USA)", Science of The Total Environment, Volume 565, 2016, Pages 401-411, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2016.04.008

309 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0572

310 Eurostat, Labour Force Survey.

311 Source for the gross value added: Eurostat 2020: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Wood_products_-_production_and_trade#Wood_based_industries and table [sbs_na_ind_r2]; employment: table [lfsa_egan22d] and Robert et al. 2020.

312 Eurostat (2021) Roundwood removals by type of wood and assortment [for_remov]

313 https://www.climate-kic.org/wp-content/uploads/2021/06/MATERIAL-ECONOMICS-EU-BIOMASS-USE-IN-A-NET-ZERO-ECONOMY-ONLINE-VERSION.pdf

314 Pohjanmies et al., (2017) Impacts of forestry on boreal forests: An ecosystem services perspective

315 EEA (2022) Forest dynamics in Europe and their ecological consequences. Available at: https://www.eea.europa.eu/publications/forest-dynamics-in-europe-and-1/forest-dynamics-in-europe-and

316 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0572

4.2.8 Distortion of competition in the EU Internal Market

The current national requirements on remediation of contaminated sites are different in the EU Member States, and hence generate different remediation costs. This is a problem, because it is susceptible to distort competition: the companies from the Member States where the remediation costs are the lower have a cost advantage compared to those where they are higher. This distortion of competition is particularly important for manufacturing, a sector open to competition within the Internal Market and also susceptible to operate on contaminated sites.

Only a few Member States have computed the consolidated future costs of all their contaminated sites, based on their national criteria for the determination of contaminated sites and on their national requirements for decontamination. These figures hence provide the only available data regarding the future site decontamination costs in the current situation where no EU Soil Health Law exists. In order to assess the burden of these remediation costs on manufacturing, the Table 4-2 below compares them to one year of value added in manufacturing.

Table 4-2: Comparison of the overall estimated costs of remediation of contaminated sites to the value added of manufacturing

Country	Overall management costs (EUR million)	Value added in manufacturing per year (EUR million, 2018)	Overall remediation costs related to manufacturing value added per year
Austria	12.000,00	64.836,00	18,5%
Belgium (Flanders)	7.000,00	(e) 39.185,28	17,9%
Switzerland	4.700,00	112.131,00	4,2%
Hungary	3.330,00	25.174,00	13,2%
Slovakia	2.790,00	16.969,00	16,4%
Estonia	8,75	3.493,00	0,3%
Lithuania	1.300,00	7.546,00	17,2%

Sources:

- *Ana Payá Pérez and Natalia Rodríguez Eugenio, "Status of local soil contamination in Europe: Revision of the indicator "Progress in the management Contaminated Sites in Europe, EUR 29124 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-80072-6, doi:10.2760/093804, JRC107508*
- *Eurostat: National accounts aggregates by industry (up to NACE A*64)[nama_10_a64]*

(e) = estimation, based on the share of Flanders in the total wages & salaries in the manufacturing sector in Belgium (Eurostat SBS data by NUTS 2 regions and NACE Rev. 2 (from 2008 onwards)[sbs_r_nu ts06_r2]

Despite the heterogeneity between Member States regarding the criteria to determine the contamination status of a site, and regarding the site remediation obligations, the anticipated burden of site remediation costs compared to one year of value added of manufacturing is surprisingly homogeneous across the few Member States, regions and neighbouring countries having provided data. Despite this general statement, some countries of the EU or competing directly with it have significantly lower burdens than the majority, and hence benefit from an undue cost advantage in their competition on the Internal Market.

ANNEX 8: BASELINE

The Baseline scenario for the assessment of the proposed Policy Options is the scenario in which no specific action additional to what is already ongoing or planned is undertaken by the European Union to promote Soil Health, so that the existing situation and trends continue (i.e. the counterfactual). This assumes the realistic implementation of:

- The recent initiatives (NRL, Revised LULUCF and Carbon removal) under the European Green Deal and the new 'CAP'
- Existing EU and Member State policies and legislation relevant for soil health;

The Soil Strategy for 2030 (except the proposed Soil Health Law);

- The pursuit of the existence and of the evolution trends of the problem.

The baseline scenario provides a critical benchmark to assess the impacts of formulated policy options. In this regard, the baseline serves the purpose of a 'counterfactual' scenario for examining how the situation is expected to change in the case of no further action on improving soil health in the EU. As such, the baseline provides an overview of the current (policy and biophysical) situation, considering economic, social, and environmental aspects, and describes expected future trends based on the current situation and extrapolation of known trends (in the absence of further policy options).

The baseline begins with an overview of the contribution of policy initiatives and legislation relevant to soil health at EU and national levels. This baseline builds on the backdrop of *existing* measures and policies *already committed*, and does not include measures projected to be implemented.

Following this, the projected impacts of policy initiatives will be developed, along with an analysis of the problem. This will be done quantitatively where possible to define, and through a qualitative narrative when quantitative data is not available. The baseline will then be presented with a specific focus to 2030 and 2050 (with historical data from 2010 being the reference point – where data is available) for which the analysis of interventions will be developed against.

1 CONTRIBUTION FROM RECENT NEW INITIATIVES (PROPOSALS ON NRL, REVISED LULUCF AND CARBON REMOVAL) AND NEW CAP.

The contribution of these 4 initiatives has been assessed since they are particularly relevant for soils.

1.1 The Nature Restoration Law (NRL) proposal

The proposed Nature Restoration Law (NRL)[317] sets targets to protect nature in the EU, and underlines that protection alone is insufficient. The core of this initiative are the legally binding EU nature restoration targets to restore degraded ecosystems (i.e. with high importance for biodiversity), and especially those with the most potential to remove and store carbon and to prevent and reduce the impact of natural disasters. The latter

[317] COM(2022)304.

issue is key to ensuring that climate mitigation objectives are met through the delivery of ecosystem services and related nature-based solutions. The NRL establishes an overarching restoration objective for the long-term recovery of nature, with measures covering at least 20% of the EU's land and sea mass by 2030, and all areas by 2050.

In particular, the NRL proposal contains three provisions directly relevant to soils: the obligation for Member States to put in place restoration measures for organic soils in agricultural use constituting drained peatlands, and two targets, to be defined by Member States, to achieve a satisfactory level of stock of organic carbon in cropland mineral soils and in forest ecosystems.

Concerning organic soils, the NRL proposal can be expected to address at best their need for restoration; however, concerning the organic content in mineral soils, the NRL may not be expected to be optimally effective, since it could not yet profit of the most recent knowledge on soil monitoring indicators and thresholds made available by EEA – in its final version – at the beginning of 2023. This new knowledge allows to better address the evolution of the problem of loss of soil carbon, by identifying common indicators and target ranges on soil organic carbon at EU level.

The proposed NRL is expected to positively influence soil health throughout Europe as the efforts required to achieve 'good condition' in each of the ecosystems encompassed by the law will be required to implement measures to enhance the status of habitats listed in 'bad/poor condition'. Although actions undertaken by MSs to achieve these objectives (through developing 'national restoration plans' and implementing measures) will likely focus on those which are the most cost-effective (potentially meaning that often costly soil remediation works being overlooked), it is expected that significant positive impacts on soil health will be delivered.

1.2 Revised LULUCF regulation

The LULUCF regulation (2018/841) sets out commitments, targets and accounting rules for MS that are applicable to emissions and removals of GHG emissions resulting from land use and land use change and forestry (LULUCF) activities. The LULUCF regulation aims to incentivise MS to take appropriate policy action domestically to reach these targets, though does not impose rules on individual actors such as farmers and foresters.

For the period 2021 to 2025, the regulation sets a commitment for each MS to ensure that accounted emissions from land use are entirely compensated by an equivalent amount of removal of CO_2 from the atmosphere through action in the sector, also referred to as the 'no-debit' rule. For the period beyond 2026, the Regulation covers all land uses and land use change, including wetlands and settlements.

The EU Green Deal and the EU Climate Law, have stepped up the role of the land sector in mitigating climate change and reversing a declining trend of the EU land sink (notably that of managed forests). Member States therefore now have from 2026 onwards individual binding targets, based upon the information reported to the UNFCCC, with certain degrees of flexibilities, which combine to reach net carbon removals of 310 Mt CO_2 in 2030 for the EU. These new targets, which include the scope of soil carbon, are an incentive for Member States to promote soil management measures that strengthen the capacity of soils to preserve and sequester carbon. The regulation requires that MS use geographically explicit digital data, and establish a system for the monitoring of soil carbon stocks (inter alia, LUCAS).

The main impact that the revised LULUCF regulation could have on soils is through the specific and transparent inclusion of the greenhouse gas flux to the soil carbon pools under all land uses, in respect of each Member State's target. This framework would help Member States develop and implement sustainable management practices that enhance the capacity of soils within their territory to deliver carbon sequestration and other ecosystem services.

1.3 The Carbon removal initiative

The land sector is key for reaching a climate-neutral economy, because it can capture CO_2 from the atmosphere.

The Communication on Sustainable Carbon Cycles[318] sets out short- to medium-term actions aiming to address current challenges to carbon farming in order to upscale this green business model that rewards land managers for taking up practices leading to carbon sequestration, combined with strong benefits on biodiversity. These include:

- promoting carbon farming practices under the Common Agricultural Policy (CAP) and other EU programmes such as LIFE and Horizon Europe, in particular under the Mission "A Soil Deal for Europe", and under public national financing;
- driving forward the standardisation of monitoring, reporting and verification methodologies to provide a clear and reliable framework for carbon farming;
- providing improved knowledge, data management and tailored advisory services to land managers.

Examples of effective carbon farming practices include:

- Afforestation and reforestation that respect ecological principles favourable to biodiversity and enhanced sustainable forest management, including biodiversity-friendly practices and adaptation of forests to climate change;
- Agroforestry and other forms of mixed farming combining woody vegetation (trees or shrubs) with crop and/or animal production systems on the same land;
- Use of catch crops, cover crops, conservation tillage and increasing landscape features: protecting soils, reducing soil loss by erosion and enhancing soil organic carbon on degraded arable land;
- Targeted conversion of cropland to fallow or of set-aside areas to permanent grassland;
- Restoration of peatlands and wetlands that reduces oxidation of the existing carbon stock and increases the potential for carbon sequestration.

The proposal on Carbon removal Regulation[319] (announced in the Communication on sustainable Carbone Cycles) aims to facilitate the deployment of high-quality carbon removals through a voluntary Union certification framework with high climate and environmental integrity. Storing carbon in soil is an essential component of reaching climate neutrality. At the same time, carbon removals constitute a new business model in

[318] COM(2021)800 final
[319] COM(2022)672 final.

the voluntary market with carbon credits. This initiative is instrumental in ensuring soil's capacity to absorb and store carbon.

1.4 The new Common Agricultural Policy (CAP)

The Common Agricultural Policy (CAP) consists of two pillars and has three main areas of action: direct support (first pillar), market measures (first pillar) and the rural development policy (second pillar). Direct support consists of payments granted directly to farmers. Market measures are used to level the playing field and tackle volatile costs of inputs such as fuel and fertilizer. Furthermore, the rural development policy is a tool that supports the sustainable development of the EU's rural areas and agriculture, through for example agri-environment and climate measures, such as organic farming, advisory services, or investment measures. One of its objectives relevant to soil protection is to ensure sustainable management of natural resources and climate action.

On 2/12/2021 the agreement on the reform of the CAP was adopted (2023-2027), which focusses on making a stronger contribution towards sustainable agriculture and forestry in the EU. The new ambitions are built around ten objectives, those relevant to soils are analysed below.

From these objectives, 4 (climate change action), 5 (environmental care), 6 (to preserve landscapes and biodiversity) and 9 (to protect food and health quality) could have soil health (co-)benefits, while actions under objective 2 (increasing competitiveness) could incur negative soil impacts (scale unknown). Objectives 4 and 5 overlap in promoting the role of agriculture in enhancing carbon sequestration, whilst these objectives also promote the protection of wetlands and peatlands through Good Agricultural and Environmental Conditions[320] (GAEC) 2. GAEC 2 explicitly states that MSs must ensure appropriate protection of wetlands and peatlands (outlining their important role in carbon sequestration), yet MSs can delay the implementation of this until 2025 and 14 have already requested a derogation of this conditionality, meaning the current status quo of wetland degradation can be expected until at least 2025.[321] Linked to objective 5 are also a range of GAECs which seek to improve soil conditions: GAEC 5 sets requirements for tillage management for erosion control, GAEC 6 requires farmers to avoid leaving the soil bare during sensitive periods, and GAEC 7 requires farmers to apply crop rotation. These standards ensure safeguards across the EU, their precise definition and requirements, however, vary between Member States, leave room for derogations and do not include quantified targets.

Under objective 6, an increase in landscape features can be expected, which could either directly (e.g. control of soil erosion) or indirectly (less need for chemical inputs as landscape features provide a habitat for pest enemies) affect soil health. Landscape features are targeted by GAEC 8, requiring farmers to devote 4% of their land to non-productive areas and features. This share can be reduced to 3 % if Member States opt for including catch crops and nitrogen-fixing crops,[322] which have to account for another 4%

[320] **Good agricultural and environmental conditions**, abbreviated as **GAEC**, refers to a set of European Union (EU) standards (described in Annex II of Council Regulation No 1306/2013 defined at national or regional level), aiming to achieve a sustainable agriculture. Keeping land in good agricultural and environmental conditions is directly related to issues such as minimum level of maintenance, protection and management of water, soil erosion, soil organic matter or soil structure.
[321] EEB and Birdlife (2022) Peatlands and wetlands in the new CAP: too little action to protect and restore. Available at: https://www.birdlife.org/wp-content/uploads/2022/04/Analysis-Peatlands-Wetlands-CAP-strategic-plans-April2022.pdf
[322] EEB and Birdlife (2022) Space for nature on farms in the new CAP: not in this round

but which, as evaluated from the previous CAP, have very little benefit to biodiversity.[323] Additional benefits might occur where Member States established eco-schemes to further increase the share of non-productive areas. The extent to which those measures will be implemented is however not yet possible to estimate.

Table 1-1: Summary overview of GAECs with high relevance for Soil Health Law

GAEC	Issue addressed
GAEC 2	Requirement to ensure appropriate protection of wetlands and peatlands
GAEC 3	Establishing a ban on burning stubble
GAEC 5	Setting requirements for tillage management for erosion control
GAEC 6	Setting a requirement to farmers to avoid leaving the soil bare during sensitive periods
GAEC 7	Setting a requirement to farmers to apply crop rotation
GAEC 8	Setting a requirement for farmers to devote 4% of their land to non-productive areas and features

Finally, objective 9 (to protect food health and quality) particularly focuses on reducing antimicrobial resistance (AMR). As it targets reduced use of veterinary antimicrobials and instead promotes a farm specific health plan for disease prevention, less contaminant input to soils would logically result, yet the scale of this is not known.

To improve the environmental performance of the CAP, a new feature is the implementation of eco-schemes- to which 25% of direct payments in each MS should be devoted to (most MSs achieve or surpass this in their strategic plans). An overview of the thematic coverage of MS strategic plans (relevant to soils) in relation to eco-schemes are presented below.

Table 1-2: Eco-schemes under the CAP and number of MSs which address this through their strategic plans

Issue	Number of MSs which address the issues through at least one eco-scheme
Biodiversity, landscape features, non-productive areas	25
Carbon sequestration/ carbon farming	8
Integrated Pest Management/ pesticide management	11
Nutrient management	12
Precision farming	6
Permanent pastures	12
Soil conservation practices	26
Organic farming	12

Source: EC (2022) Proposed CAP Strategic Plans and Commission observations- Summary overview for 27 Member States. Available at: https://agriculture.ec.europa.eu/system/files/2022-07/csp-overview-28-plans-overview-june-2022_en.pdf

MSs are also obliged to establish targets in their Strategic Plans which outline their desired results (or intended uptake of interventions) through results indicators. Through

[323] ECA (2017) Special Report No 21, Greening: a more complex income support scheme, not yet environmentally effective

analysing these, it is possible (at a high level) to gain an overview of how MSs intend to fund interventions to achieve CAP objectives and actions under the eco schemes outlined above. The table below presents an overview of a selection of these result indicators relevant to soils.[324]

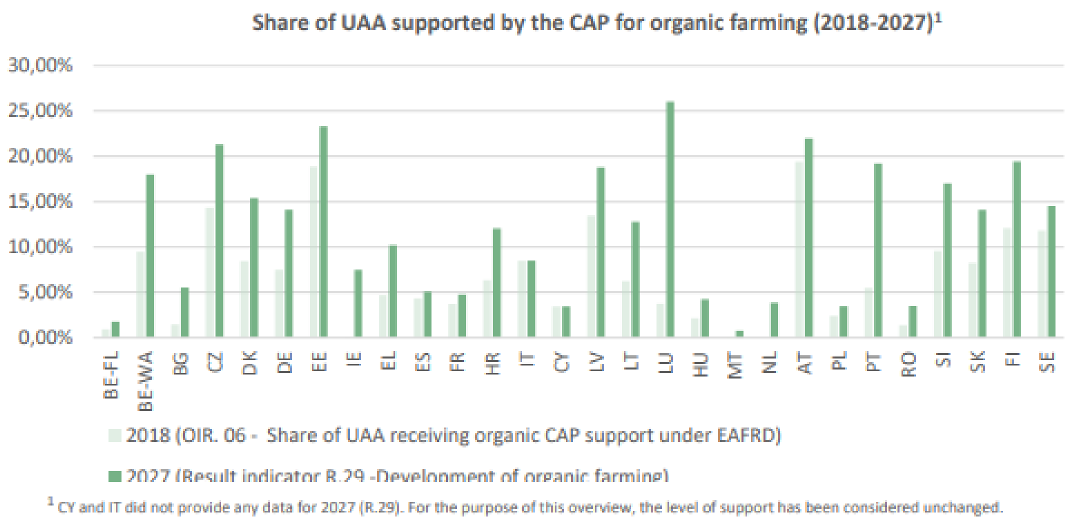
Table 1-3: Range of result indicator target values in CAP strategic plans

Result indicator	Range of target value in draft CAP Strategic Plans (expressing the agricultural area intended to be subject to relevant area-based support, as a % of each Member State's total utilised agricultural area)
R.14 – Carbon storage in soils and biomass	from 2% to 86% in 22 strategic plans, with the half of them below 31% and 5 above 50%
R.19 – Improving and protecting soils	from 7% to 86% in 24 strategic plans with half of them below 32% and 9 above 50%
R.24 – Sustainable and reduced use of pesticides	from 1.3% to 56% in 23 strategic plans, with 9 below 10%
R.31 – Preserving habitats and species	from 1.4% to 99.5% in 23 strategic plans; with 11 of them below 21% and 3 above 75%

Source: EC (2022) Proposed CAP Strategic Plans and Commission observations- Summary overview for 27 Member States. Available at: https://agriculture.ec.europa.eu/system/files/2022-07/csp-overview-28-plans-overview-june-2022_en.pdf

When observing MS ambitions in relation to organic farming from strategic plans, the figure below shows the majority of MS seek to enhance the share of utilised agricultural are receiving support from the CAP up to 2027 compared to the previous programming period.

Figure 1-1: Percentage of utilised agricultural area per MS supported by CAP organic farming



Source: Taken from: EC (2022) Proposed CAP Strategic Plans and Commission observations- Summary overview for 27 Member States. Available at: https://agriculture.ec.europa.eu/system/files/2022-07/csp-overview-28-plans-overview-june-2022_en.pdf

[324] EC (2022) Proposed CAP Strategic Plans and Commission observations- Summary overview for 27 Member States. Available at: https://agriculture.ec.europa.eu/system/files/2022-07/csp-overview-28-plans-overview-june-2022_en.pdf

It should be noted that the extent to which the CAP contributes to soil health objectives varies widely between Member States. The two result indicators attributed to soil under the CAP illustrate these differences (R.14 'Carbon storage in soils' and R.19 'Improving and protecting soils''). They are designed to indicate the targets for the different objectives under the CAP and to allow monitoring of their implementation. The EU average in the two figures below represent the average of the respective indicator reported in all CAP Strategic Plans. Measures related to carbon storage in soils (R. 14) affect on average 41% of the utilised agricultural area (UAA) of a Member State. Measures related to soil improvement and protection (R.19) affect on average 46% of a Member State's UAA. It is important to highlight the large differences between Member States (for R.14 between 6% of the Member States' UAA (Malta) to 92% (Luxembourg) and for R. 19 between 11% (Ireland) to 92% (Luxembourg)), and their respective share of the total agricultural area of the EU and thus the corresponding area effect.

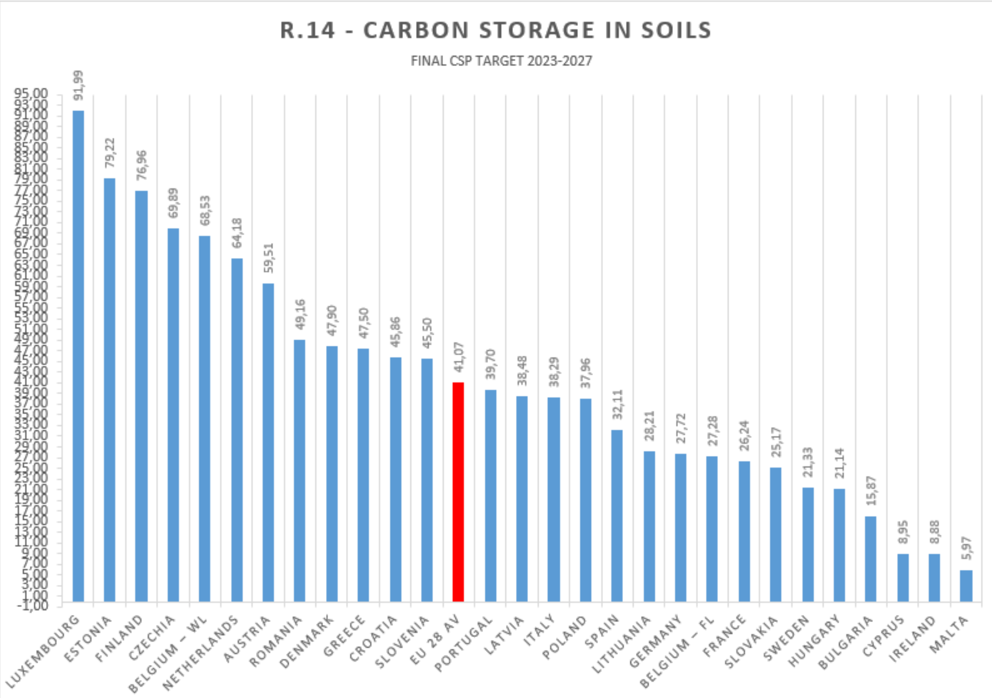


Figure 1-2: CAP result indicator R.14: Carbon storage in soils and biomass: Share of utilised agricultural area (UAA) under supported commitments to reduce emissions or to maintain or enhance carbon storage (including permanent grassland, permanent crops with permanent green cover, agricultural land in wetland and peatland)

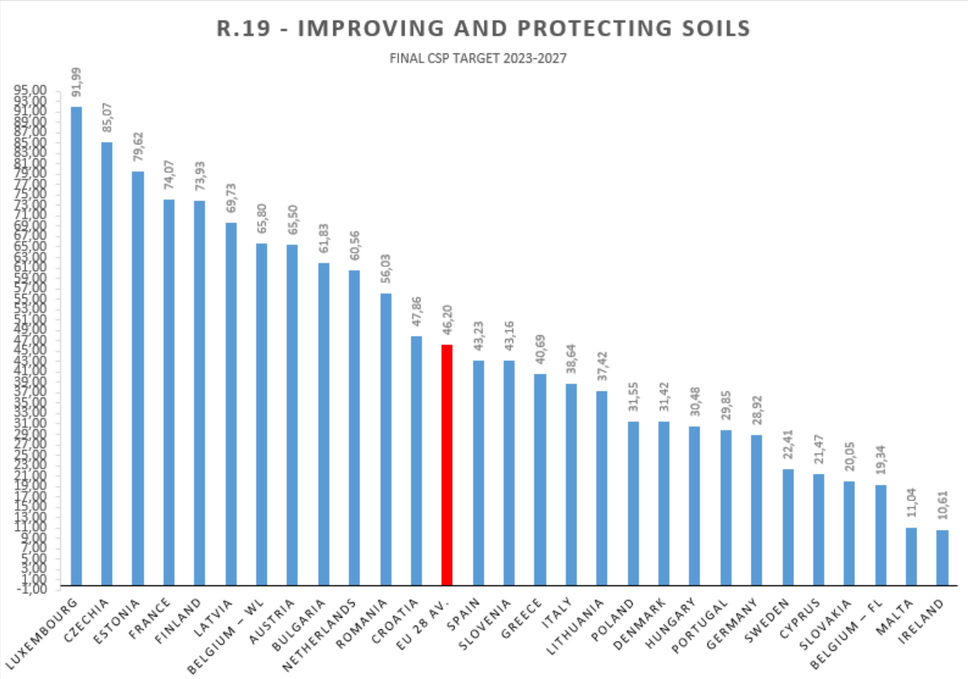


Figure 1-3: CAP result indicator R.19: Improving and protecting soils: Share of utilised agricultural area (UAA) under supported commitments beneficial for soil management to improve soil quality and biota (such as reducing tillage, soil cover with crops, crop rotation included with leguminous crops)

Overall, it is challenging to estimate the projected impacts of the CAP moving forward, with Member States providing a significantly varying degree of commitment to achieving the prescribed objectives of the CAP. It is also worth acknowledging the evaluation of the previous CAP, which outlined that the extent to which the relevant CAP instruments and measures contributed to sustainable soil management and impacted soil quality and productivity were difficult to establish.[325] Furthermore, the scope of the financial support offered under the CAP also has its limitations. The previous CAP provided a framework with a broad range of instruments and measures to foster sustainable management of soils. However, evaluations[326] showed that few of the activities necessary for soil protection are enforced at EU level and that key practices, such as controlled traffic, no/reduced/late tillage diversified crop rotation and compost application, as well as the limitation of plot size are in no cases enforced by the EU regulation. Except for crop rotation, which is now covered under GAEC 7, these general conditions remain the same, as does the observation that the level of priority given to address soil quality seems to result mostly from the level of awareness among national and local authorities of the threats to soil and their possible consequences. A key recommendation of the 2020 evaluation support study on the impact of the CAP on sustainable management of the soil[327] was to establish an EU framework that ensures common definitions of soil and soil threats are adopted across the Member States and sets common definition for sustainable soil management and soil conservation agriculture. It as found that ensuring the adoption of common definitions of soil, sustainable soil management, conservation agriculture and soil threats is a prerequisite to fostering coordination among Member States or regions

[325] See https://op.europa.eu/en/publication-detail/-/publication/85bd465d-669b-11eb-aeb5-01aa75ed71a1/language-en

[326] https://www.ecologic.eu/sites/default/files/publication/2022/3591-Evaluation-Support-Study-on-The-Impact-of-The-CAP-on-Sustainable-Management-of-The-Soil-web.pdf

[327] https://www.ecologic.eu/sites/default/files/publication/2022/3591-Evaluation-Support-Study-on-The-Impact-of-The-CAP-on-Sustainable-Management-of-The-Soil-web.pdf

and for facilitating the spread of conservation practices in the EU, but also research on those practices and the design of instruments to support conservation practices. While the design of the new CAP does not include this recommendation, it would be precisely targeted under the new soil health law.

1.5 Assessment of the contributions of these initiatives

The contribution of these 4 initiatives to address the different soils threats has been assessed for the different soils (agriculture, forest and other).

The major contribution of these initiatives (i.e NRL, revised LULUCF, Carbon Removal and new CAP) concerns the **loss of soil organic carbon**. For SOC in organic soils, the attainment of the targets set in the proposed NRL is considered as sufficient to reach the corresponding criteria for healthy soils. The revised LULUCF and carbon farming will incentivize soil management measures that strengthen the capacity of soils to preserve and capture CO_2. Regarding mineral soils, these initiatives if fully implemented partially addresses the problem.

As regards **soil erosion** on agricultural soils, the new CAP includes some safeguards, especially by two GAECs on soil erosion risk management and soil cover, and certain targeted voluntary measures. This may for example decrease the extent of arable land in the EU left as bare soil without any vegetation cover during winter, which were estimated to be 23 % in 2016. However, due to different priorities and implementing requirements across the Member States it is estimated these instruments would not be suitable to cover the problem to full extent.

Soil compaction is not expected to be addressed by the above-mentioned initiatives.

Positive impacts on agriculture soils are expected from the GAEC on soil cover and crop rotation to address **the excess of nutrients**. However, not all agriculture soils are concerned and there is no binding target to be achieved. Furthermore, the target on water ecosystems as well as the restoration measures on terrestrial ecosystems under the proposed NRL is also expected to contribute to the reduction of the excess of nutrients in soils. However, this would concern a maximum of 24% of all soils. Hence it is estimated that a large gap remains.

On **soil acidification**, the target on restoration of terrestrial ecosystems under the proposed NRL may contribute to reduce soil acidification. However, this would concern a maximum of 24%[328] of all soils. Hence it is estimated that a large gap remains.

On **soil salinization**, the rewetting target under the proposed NRL may probably contribute locally to reduce soil salinization in some agricultural soils. However, only an indirect contribution is expected. Therefore, a large gap remains.

On the **loss of soil biodiversity**, some eco-schemes and AECM under the CAP are expected to have some positive impacts on agriculture soils. However, due to the voluntary nature of these measures and the great variation in availability across Member States, the potential of the CAP to fully address this problem is limited and it is estimated

[328] Page 14 of the Impact Assessment accompanying the proposal on NRL (SWD(2022) 167)

that only a small share of agricultural soil would be is currently impacted. The restoration measures under the proposed NRL would also contribute to address this problem.

On **water retention capacity**, the measures under the proposed NRL and LULUCF aiming to increase the soil organic carbon will improve the soil's capacity to retain water. However, there are no specific targets on the soil's capacity to retain water.

On soil sealing and **artificialization**, **prevention** and **remediation** of **soil contamination**, the non-deterioration of habitats under the proposed NRL may prevent from soil sealing and artificialization. Besides this, no further major contribution is expected from the 4 initiatives.

1.6 Conclusion

The recently proposed initiatives on the NRL, revised LULUCF regulation and on carbon removal regulation as well as the new CAP are expected to positively contribute to maintain or restore the soil health on some aspects. However, these initiatives even if fully implemented will not be able to achieve the objectives of the SHL initiative. A visual representation of the estimated contribution of the initiatives is inserted in Chapter 5 of the main report.

2 CONTRIBUTION OF EXISTING LEGISLATION AND POLICIES AND CONNECTIONS TO THE SOIL HEALTH

2.1 EU existing environmental legislation

An overview of the existing EU legislation and its relevance for soils can be found in annex 6.
The following sections describe in more detail the contributions of the most relevant instruments.

2.2 Environmental Impact Assessment Directive

The EIA Directive requires the assessment of the environmental effects of certain public and private projects that are likely to have significant effects on the environment. It is intended to provide a check of projects and to consult the public before authorising projects. The first EIA Directive was adopted in 1985 and amended three times, in 1997, in 2003, in 2009, and in 2014.

The Directive is relevant to soil protection since projects (e.g. infrastructure development) could have negative impacts on soil quality and quantity through various threats, e.g. soil sealing or pollution. Identifying these impacts and potentially less harmful alternatives could result in the developer choosing a method that reduces the impact on soil. The directive explicitly addresses soil as one component of the environment. It also addresses biodiversity, which could include effects of projects on soil biodiversity.

Soils will benefit from an environmental impact assessment as this covers the use of natural resources and the emissions of residues and pollutants resulting from the construction and operation of the proposed project. An example of a relevant EIA is from a case study of a highway in Slovakia, where as a result of the EIA procedure, measures to minimise soil erosion and risk of soil collapsing have been implemented. This can be of high importance, especially in the case of heavy contamination of soils and groundwater. In short, according to the EIA Directive, developers of public and private projects should assess and avoid, prevent or reduce impact on land, for example with regard to land take, and on soil, including organic matter, erosion, compaction and sealing.

Member States had to adopt their transposing legislation and communicate it to the Commission by 16 May 2017. From this date onwards, Member States must inform the Commission on the implementation of the Directive, with the first reporting exercise planned for 2023.[329] As of 2020, all Member States had transposed Directive 2014/52/EU, amending Directive 2011/92/EU. Following a thorough assessment of the transposition of the revised Directive into national legislation, infringement procedures for non-conform transposition were launched against 23 Member States.[330]

An independent study[331,332] to explore whether and how the amendment of Directive 2014/52/EU has influenced the consideration of land in EIA found that, so far, the specific EIA cases listed by the experts showed that projects affecting undeveloped land are not necessarily rejected or modified – even if an EIA concludes that they will negatively impact land. Overall, the study found that the inclusion of the factor 'land' into the Directive had not yet made a real difference. While this may be partly due to delays in Member States implementing the directive, the study concluded that obstacles remain with regard to the operationalisation (i.e., need for qualitative indicators for assessing environmental impacts of land take) and contextualisation of the factor 'land' as an aspect of EIAs (i.e., need for a concise definition of 'land' in EU Guidance Documents and full breakdown of quantitative land take targets down to the regional and local level). Most of the experts interviewed believed that the inclusion of the factor 'land' in the Directive could potentially make a difference in the future, especially by raising knowledge.

Trend data exist with regard to the rates and trends of sealing within the EU (presented in the figure below).[333]

[329] https://www.europarl.europa.eu/cmsdata/226410/Briefing_Transposition_and_implementation_of_the_2014_Directive_on_the_assessment_of_the_effects_of_certain_public_and_private_projects_on_the_environment_.pdf

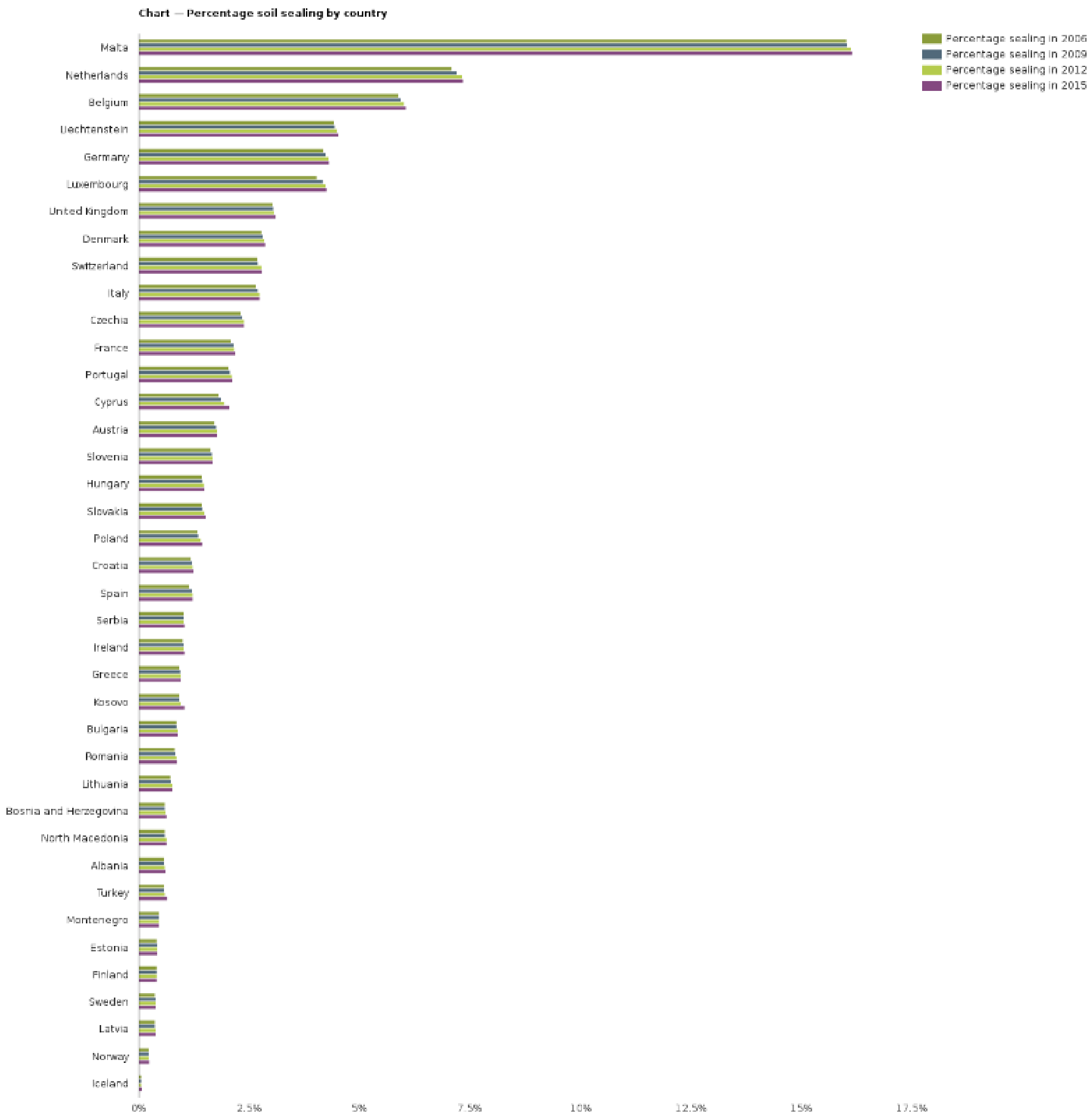
[330] https://unece.org/sites/default/files/2022-05/EU_EIA_Annex.pdf

[331] https://www.sciencedirect.com/science/article/pii/S0264837721004531

[332] Austria, Belgium, Czech Republic, Denmark, France, Germany, Italy, Latvia, Netherlands, Poland, Portugal, Spain, Sweden, UK.

[333] https://www.eea.europa.eu/data-and-maps/daviz/percentage-sealing-by-country-1#tab-chart_5

Figure 2-1: Soil sealing per EU Member State (% of total surface, 2006 to 2015)



2.3 Industrial Emissions Directive (IED)

The IED is the main EU instrument for preventing and reducing pollution from c. 52 000 large industrial installations in Europe. It aims to prevent pollution and achieve a high level of protection of human health and the environment. The IED currently regulates the environmental impacts of Europe's large-scale, high-pollution-risk industrial installations and certain livestock farms ('agro-industrial' installations of intensive rearing of pigs and poultry) in an integrated manner, on a sector-by-sector basis. It covers all relevant pollutants emitted by agro-industrial installations in significant quantities that may affect human health and the environment. Installations regulated by the IED account for about 20% of the EU's overall pollutant emissions by mass into the air, around 20% of pollutant emissions into water and approximately 40% of greenhouse gas (GHG) emissions. Activities regulated by the IED include power plants, refineries, waste treatment and incineration, production of metals, cement, glass, chemicals, pulp and paper, food and drink, and the intensive rearing of pigs and poultry. The IED addresses mainly the installations carrying out activities listed in IED annex I and does not address soil contamination caused before the entry into force of the IED.

The IED operates via a "Best Available Techniques" (BAT) permitting system. BATs are listed in BAT Reference Documents (BREFs), developed through an information exchange among experts from Member States, industry and environmental organisations, steered by the JRC/ European IPPC Bureau. The IED lays down that the concerned installations must operate according to permits, conditions of which are based on BAT conclusions. It covers emissions into air, water and land and the generation of waste, in order to achieve a high level of protection of the environment taken as a whole. For example, the BAT Conclusions for surface treatment using organic solvents including preservation of wood and wood products with chemicals include techniques to prevent or reduce emissions to soil and groundwater, such as plant or equipment containment or impermeable floors.

This Directive, which entered into force in 2011, addresses soil and groundwater protection at site level through these permits as they include environmental protection obligations. General requirements to be set in permits include appropriate requirements ensuring protection of the soil and groundwater and appropriate requirements for the regular maintenance and surveillance of measures taken to prevent emissions to soil and groundwater.

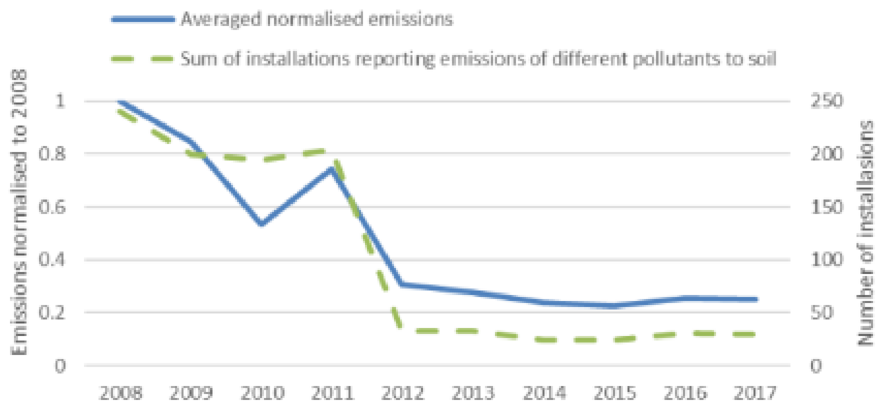
If an installation's activity involves the use, production or release of a hazardous substance which may lead to contamination of soil or groundwater, additional requirements shall apply. Firstly, the permit shall include appropriate requirements concerning the periodic monitoring of soil and groundwater in relation to relevant hazardous substances likely to be found on site and having regard to the possibility of soil and groundwater contamination at the site of the installation. Second, where the activity involves the use, production or release of relevant hazardous substances and having regard to the possibility of soil and groundwater contamination at the site of the installation, a baseline report is required. This baseline report determines the state of soil and groundwater contamination prior to the start of operation of the installation and is used as a reference point to identify changes in the level of soil and groundwater contamination. Where significant soil or groundwater pollution has been caused, the operator must take the necessary measures to return the site to the baseline level. Where the contamination of soil and groundwater at the site poses a significant risk to human health or the environment, the operator shall take the necessary actions aimed at the removal, control, containment or reduction of relevant hazardous substances, so that the site, taking into account its current or approved future use, ceases to pose such a risk.

According to the evaluation study of the IED,[334,335] very few installations report any emissions and the emissions to soil have decreased since the entry into force of the directive (Figure 2-2). However, this is mainly due to the reduction of installations that report their emissions because their emissions have decreased below the reporting thresholders.

[334] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0181

[335] https://circabc.europa.eu/ui/group/06f33a94-9829-4eee-b187-21bb783a0fbf/library/df5b7d87-2bd9-47f3-b3d3-de41d402476d?p=1&n=10&sort=modified_DESC

Figure 2-2: Trend in selected pollutant emissions to soil from IED sectors



The IED is currently being revised: the proposal for revision was adopted on 5/4/2022 and included several amendments **with a positive impact on soil quality** by preventing soil contamination.

Firstly, the EC aims to lower the threshold above which the rearing of pigs and poultry are included within the scope of the directive, to improve air, water and soil quality. In addition, the Commission proposed to include cattle within the scope of the IED, above a certain threshold. These series of amendments, which will also contain the adoption of an implementing act setting operating rules, including on sustainable management and land spreading practices; will lead to a decrease of pollutant emissions from livestock activities to air, water and soil.

Concerning industrial activities, the tightening of the setting of emission limit values in permits, for pollutant emissions to air, water and land/soil, as well as of flexibility or derogations provisions, are also expected to have a positive impact on soil quality.

Moreover, BAT conclusions are proposed to be extended to landfills as technical developments and innovation have made more effective techniques available for the protection of human health and the environment. This could also positively impact pollutant emissions to soils as not properly managed landfills are sources of groundwater and soil pollution.

Besides, the proposed scope extension of the IED to certain mining activities will allow the development of BATs for these activities. Although the size of impacts will ultimately depend on the outcome of the BAT process for these mining activities, there is significant potential to reduce emissions to surface water, groundwater and soil by applying the IED's integrated permitting framework

2.4 Environmental Liability Directive (ELD)

The ELD establishes a framework based on the polluter pays principle to prevent and remedy environmental damage. 'Environmental damage' is defined as damage to protected species and natural habitats, damage to water and damage to land. The concept of 'environmental damage' is further explained in the commissions notice (2021) with guidelines providing a common understanding of the term 'environmental damage'. Land damage is restricted to 'significant risk to human health being adversely affected', which means that significant risks for the environment are not covered by the ELD. However, some Member States use a broader definition which includes a risk to the environment or a risk for infringing certain limit values of pollutants.

The ELD only addresses new contamination of soils, if it reaches a certain significance threshold (i.e. contamination should pose a significant risk to human health, risk to the environment is not considered). Historical contamination as a consequence of activities carried out and finished before 30 April 2007, are not covered by the directive, as well as contamination caused by risk activities that are not listed in annex III and hence do not fall under its scope. The ELD only regulates the liability for land damage and does not address issues like the identification, registration or risk assessment of contaminated sites. It also does not cover other forms of land damage or soil degradation such as erosion, sealing, loss of organic matter, etc.

The ELD aims to effectively address prevention and remediation of environmental damage in the EU, thus contributing to safeguarding European waters and to protecting the soil quality. Under the ELD land damage and imminent threat thereof make up more than half of all incidents reported in 2016 by MS[336] (747 instances). This is however not unexpected, because this damage category requires a lower remediation standard and demands less remedial action compared to water and biodiversity damage (as there is no requirement for economic valuation and for complementary and compensatory remediation for soil damage).

According to the Evaluation of the environmental liability directive in 2016[337] the definition 'significant risk of human health' with regard to the significance thresholds for land damage is quite narrow. Because of this narrow scope the impact of the ELD on the protection of soils may be limited. Furthermore, 'land damage' could be defined more precisely, e.g. by setting specific limit or screening values for certain pollutants in certain soil types. Currently, a new evaluation is ongoing which is set to be completed by 2023.

2.5 Environmental Crime Directive

The Environmental Crime Directive (2008/99/EC) aims to enhance compliance with the EU environment protection legislation by supplementing administrative sanctions regime with criminal law penalties. Under the Directive, environmental crime comprises a broad range of illicit activities, including the illegal discharge of substances into soil and the illegal dumping of waste, amongst other activities. The recent evaluation of this Directive concluded that it has not fully met its objectives and that – despite some progress – significant divergence remains between Member States. The evaluation shows the number of convictions for environmental crimes in each MS, however the data are not granular enough to identify convictions specifically related to soil.[338] Moreover, the conclusion on effectiveness is that shortcomings in enforcement remain an obstacle.[339]

Following an evaluation of the 2008 Environmental Crime Directive, the Commission adopted a proposal for the Environmental Crime Directive (15-12-2021) to crack down on environmental crime. In relation to soil, this proposed Directive includes reference to damage to soil in the definition of several criminal offences. The proposal includes elements to be considered when assessing whether a damage (including to soil) is substantial and whether an activity is likely to cause damage (including to soil). The

[336] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52016SC0121
[337] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52016SC0121
[338] https://ec.europa.eu/info/sites/default/files/evaluation_-_swd2020259_-_part_2.pdf
[339] https://ec.europa.eu/info/sites/default/files/evaluation_-_swd2020259_-_part_1_0.pdf

proposal includes detailed provisions on sanctions for natural and legal persons as well as on ‘aggravating factors’, such as the extent to which the offence caused destruction or irreversible or long-lasting damage to an ecosystem and ‘mitigating circumstances’ such as the extent to which the offender restores nature to its previous condition.

The proposal, which has not yet entered into law and may therefore be further adjusted, contains the following changes compared to the 2008 Directive: introduction of new categories of environmental crimes, setting of a minimum and maximum level for sanctions, introduction of ancillary sanctions, a definition of aggravating circumstances, mechanisms and resources to strengthen the enforcement chain, and an obligation for Member States to collect reliable statistical data and to support and assist people who report environmental offenses and cooperate with law enforcement. Ultimately, the reduction of environmental crime is expected to have a beneficial impact on the environment – including soils – via pollution reduction, although the expected impacts on soil are not quantified.

2.6 Strategic Environmental Assessment (SEA) Directive

The Strategic Environmental Assessment (SEA) and focusses on certain public plans and programmes while the EIA focusses on public and private projects. The SEA Directive covers plans and programmes prepared or adopted by an authority (at national, regional or local level) and required by legislative, regulatory or administrative provisions.

An SEA is mandatory for plans and programmes in several domains which can have an impact on soils (notably agriculture, forestry, industry, transport, waste/ water management, town & country planning or land use) and which set the framework for future development consent of projects listed in the EIA Directive. In other domains (not listed under the Directive), an SEA is needed if the plan or programme is likely to have significant environmental effects, including on soil. Moreover, an SEA is mandatory for plans and programmes which have been determined to require an assessment under the Habitats Directive.

Environmental reports must be prepared to assess the likely significant effects of implementing the plan or programme. The environmental report has to describe the likely significant effect, inter alia, on soil. Member States are required to take into account the results of the public consultation during the preparation of the plan or programme. before its adoption or submission to the legislative procedure. Moreover, they must communicate how environmental considerations have been integrated into the plan or programme after its adoption. As such, the SEA Directive contains provisions which allow the identification of the likely significant effect on soils, as a result of plans or programmes implementation, and prescribe appropriate mitigation measures.

A recent evaluation of the Directive concluded that it is fit for the purpose. Some respondents from the targeted survey conducted in the scope of this evaluation nonetheless noted that soil protection should be better integrated into plans and programmes.[340] At the same time, it should be noted that the quality of the environmental

[340] See https://ec.europa.eu/environment/eia/pdf/REFIT%20Study.pdf

report prepared in the SEA procedure rests on the Member State authorities. This also applies to the content of the plans and/or programmes.

2.7 Water Framework Directive (and Daughter Directives)

The main aim of the Water Framework Directive (WFD) is to protect and enhance the status of aquatic ecosystems in the EU, through preventing the depletion of natural water resources, protecting and improving the aquatic environment, reducing pollution of groundwater, and mitigating the effects of floods and droughts. A series of interrelated, complementary Directives also align with these objectives – namely the Environmental Quality Standards Directive (which seeks to achieve good surface water chemical status) and the Groundwater Directive (which seeks to prevent and control groundwater pollution). At the crux of the WFD, MSs are required to prevent further degradation of their water bodies, and for those which do not meet environmental objectives, actions known as Programmes of Measures (PoMs) must be undertaken to rectify this. PoMs under the WFD are encouraged to benefit the Daughter Directive obligations. For example, the implementation of actions to improve the quality of groundwater sources (such as pesticide management, crop rotation practices) can also lead to direct benefits to soils (through the improved filtering properties of soil).

The WFD takes on a ‘river basin’ approach, which requires holistic management not only to respective water bodies, but also the proximate landscapes. As such, PoMs are scoped towards tackling both water and land-based pressures, including pressures placed upon soils. However, an appropriate caveat is worth considering – the extent to which a pressure causes damage to soils may be different to the extent it causes damage to a water body, therefore PoMs may only partially address soil-related pressures (as the focus is placed on meeting water body objectives). MSs can decide upon the PoMs they will implement to tackle identified pressures, and no soil protection objectives are present within the Directive (nor Daughter Directives). Given the level of detail included in MSs River Basin Management Plans (which only detail PoMs at a high-level), it is unclear the extent to which soil issues are integrated within these documents, nor the extent to which measures have impacted soil health. As such, despite likely positive impacts of the WFD and Daughter Directives on soils, a quantitative estimate (current nor projected) is possible.

2.8 Floods Directive

The Floods Directive aims to establish a framework for the assessment and management of flood risks to reduce the negative consequences of flooding on human health, economic activities, the environment and cultural heritage in the EU. It elicits MSs to implement a three step process: conduct national preliminary flood risk assessments, produce flood hazard and risk maps, and putting in place flood management plans.

No binding or voluntary requirements are specifically dedicated to soil protection, but the Directive has the potential to impact soil health due to MS actions to tackle drivers of flooding: soil erosion, compaction and soil sealing. The Floods Directive drives MSs implementation of flood management measures within their respective Flood Risk Management Plans (FRMPs), whereby MSs are required under Article 7.2 to *“establish* *appropriate objectives for the management of flood risks"*.[341] In principle, many of the potential measures implemented by MSs within FRMPs could improve soil management practices and improve overall soil structure (through, for example natural water retention measures (NWRMs), forestry measures, floodplain expansion, re-meandering of rivers). However, the impacts of the Directive on the aforementioned drivers of flooding cannot be estimated whilst an additional complexity must be considered in relation to downstream impacts (the majority of measures implemented under the Directive are to protect human health and economic activity, therefore flood prevention measures in population/economic activity-dense areas can still incur (negative) downstream impacts on soils). Furthermore, a significant proportion of MSs have been shown to develop objectives (and consequently measures) which are not measurable[342] meaning that correlation between measures implemented and impacts are unable to be drawn. Despite this, the proactive approach encouraged by the Directive to reduce flood risk is expected to continue to positively influence, inter alia, development planning through encouraging holistic flood risk management- which encompasses measures which positively influence soil health. Ultimately, the actions promoted by the Directive will be required moving forward, especially when considering the past and future trends of flooding in the EU. For example, studies have shown an increase in the annually inundated area and number of people affected in the EU in the last 150 years, despite an overall decrease in financial losses per year (acknowledging many smaller floods being unreported). [343] Approximately EUR 150 billion in lost GDP between 2000-2013 is estimated in the EU,[344] whilst approximately 38% (the largest proportion to a natural disaster type) of economic losses caused by weather- and climate-related extreme events in EEA countries in the period of 1980-2015 were attributed to floods.[345] Under projected climate models, due to the increased frequency and severity of flooding expected in the EU in the short-medium term, the annual damages attributed to flooding are projected to increase in correlation with respective temperature rise scenarios (in G20 countries, annual damages from river flooding are projected to cost EUR 21 billion by mid-century and EUR 30-40 billion by 2100 under a relatively moderate temperature increase scenario, and over EUR 70 billion under a high emission increase scenario).[346]

2.9 Nitrates Directive

The Nitrates Directive aims to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface waters. It requires MS to identify Nitrate Vulnerable Zones (NVZ) and set up action plans for these zones to control pollution caused by manure from intensive livestock production and excessive use of inorganic fertilizers. The implementation is built around six main points. The identification of water polluted or at risk of pollution, designation of NVZs, establishment of codes of good agricultural practices (voluntary), establishment of action programmes to be implemented by farmers within NVZs (mandatory), establishment of thresholds applicable to NVZs and national monitoring and reporting.

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[341] European Commission (2019) 31 Final, European Overview – Flood Risk Management Plans, online at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=SWD:2019:31:FIN&qid=1551205988853&from=EN
[342] European Commission SWD. 2019. 31 final, European Overview - Flood Risk Management Plans, online at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=SWD:2019:31:FIN&qid=1551205988853&from=EN
[343] Paprotny et al. (2018) Trends in flood losses in Europe over the past 150 years.
[344] EEA. 2016. River floods. Online at: https://www.eea.europa.eu/data-and-maps/indicators/river-floods-2/assessment
[345] EEA. 2017. Climate change adaptation and disaster risk reduction in Europe. Enhancing coherence of the knowledge base, policies and practices. EEA Report No 15/2017.
[346] EEA (2022) Briefing- Economic losses and fatalities from weather- and climate-related events in Europe. Available at: https://www.eea.europa.eu/publications/economic-losses-and-fatalities-from/economic-losses-and-fatalities-from

The Nitrates Directive has no explicit soil-focused measures, but sound soil management practices and measures do contribute to its aim. Relevant to soils are the establishment of codes of good agricultural practices, which are voluntary, but include use of cover crops to prevent nitrate leaching and crop rotations. Within the action programmes to be implemented by farmers within NVZs mandatory measures are included, such as the limitation of fertilisation application, taking into account crop needs, all nitrogen inputs and soil nitrogen supply and the maximum amount of livestock manure to be applied.

These aforementioned measures can have an impact on soil health by reducing traffic and stocking rates, which consequently decrease the risk of soil compaction. Besides this, establishing limits on fertilizer usage can also have the benefit of reducing diffuse soil contamination. Data on the exact impacts of the Directive on fertiliser use are not available; nevertheless, the Nitrates Report 2016-2019 concluded that the implementation and enforcement of the Nitrates Directive has cut off nutrient losses from agriculture over the last 30 years, and that without the Directive the levels of water pollution in the EU would be significantly higher. Further improvements in water quality have however been very slow since 2012.[347] It is therefore projected that current nitrate contamination trends will not significantly decrease in the future.

2.10 National emission ceilings / National Emissions reduction commitments Directive (NECD)

The NEC directive[348] highlights the importance of MS regularly reporting air pollutant emission inventories for assessing progress and compliance with their commitments. The NEC requires that MS draw up National Air Pollution Control Programmes that should contribute to the successful implementation of air quality plans established under the EU's Air Quality Directive. The AAQD introduces a number of reporting requirements on the following pollutant types: NOx, NMVOCs, SO2, NH3, PM2.5 and CO; also particulate matter (PM10), black carbon (BC) and total suspended particulate matter (TSP); heavy metals such as cadmium (Cd), lead (PB), and mercury (Hg) and if available arsenic, chromium, copper, nickel, selenium and zinc; and persistent organic pollutants (POPs) including PAHs, dioxins and furans, PCBs and HCB.

This directive is especially relevant to the diffuse contamination of agricultural soils and loss of soil quality associated in particular with acidification but also wider contamination. Some of the measures relate to controlling ammonia emissions and aim at promoting the replacement of inorganic fertilisers by organic ones or spreading manures and slurries in line with the foreseeable nutrient requirement of the receiving crop or grassland with respect to nitrogen and phosphorous. Other measures relate to controlling emissions of fine particulate matter and black carbon and aim to improve soil structure through incorporating harvest residue or improve the nutrient status and soil structure through the incorporation of manure.

Given that the EU-27 countries have maintained emissions below the ceilings designated since 2010, and the pollutants included under the scope of the Directive have all reduced in this timeframe, it is likely that this trend will continue in the future. However, this Directive does not cover the other pollutants noted in section 7.1.2 below – namely

[347] https://op.europa.eu/en/publication-detail/-/publication/2596c08f-2a8b-11ec-bd8e-01aa75ed71a1/language-en
[348] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2016.344.01.0001.01.ENG

microplastics, emerging pollutants, POPs, and heavy metals. Exposure of ecosystems to acidification in the EU-28 has been decreasing, with the area where critical loads are reached decreasing from 43 % in 1980 to 7 % in 2010.[349]

2.11 Sewage Sludge Directive

The Sewage Sludge Directive (86/278/EEC) seeks to encourage the use of sewage sludge in agriculture and to regulate its use in such a way as to prevent harmful effects on soil, vegetation, animals and man. To this end, it regulates the use of sludge considering different types of agricultural land use as well as soil and sludge quality. The Directive prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil.

The Directive directly addresses soil contamination with heavy metals and pathogenic organisms. It sets maximum values of concentrations of heavy metals and bans the spreading of sewage sludge when the concentration of certain substances in the soil exceeds these values. In addition, the Directive sets time restrictions for the sludge application in order to provide protection against potential health risks from residual pathogens. Indirectly, the directive contributes to reducing soil erosion and increasing soil organic matter, as sewage sludge is rich in nutrients and contains valuable organic matter. Sewage sludge may furthermore improve the physical and chemical properties of soil, thereby potentially enhancing soil biodiversity.

2.12 POP Regulations

The POPs Regulation (**2019/1021)** aims to protect human health and the environment with specific control measures that:

- prohibit or severely restrict the production, placing on the market and use of POPs;
- minimize the environmental release of POPs that are formed as industrial by-products;
- make sure that stockpiles of restricted POPs are safely managed; and
- ensure the environmentally sound disposal of waste consisting of, or contaminated by POPs.

POPs are of particular relevance to soil health due to their persistency, not only at particular sites (waste dumping, production sites, storage sites) but also due to their long-range environmental transport. Furthermore, stockpiling of POPs is particularly relevant to soil protection because POPs often coincide with contaminated sites. The POPs Regulation includes a specific reference to contaminated sites in Article 9 (namely that when Member States are preparing and updating their implementation plans, the Commission, supported by the Agency, and the Member States shall exchange information on the content, including information on measures taken at national level to identify and assess sites contaminated by POPs, as appropriate).

[349] https://www.eea.europa.eu/data-and-maps/indicators/exposure-of-ecosystems-to-acidification-14/assessment-2

3 EU Soil Strategy

The EU Soil Strategy for 2030[350] sets out a framework and concrete measures to protect and restore soils and ensure that they are used sustainably. It sets a vision and objectives to achieve healthy soils by 2050. The EU Soil Strategy aims to ensure that, by 2050:

- All EU soil ecosystems are healthy and thus more resilient and can therefore continue to provide their crucial ecosystem services;
- Protecting soils, managing them sustainably and restoring degraded soils has become the norm.

The Soil Strategy reconfirms several existing objectives that are relevant in relation to soil health:

For 2030:

- Combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world (Sustainable Development Goal 15.3).[351]
- Significant areas of degraded and carbon-rich ecosystems, including soils, are restored.[352]
- Achieve an EU net greenhouse gas removal of 310 million tonnes CO_2eq per year for the land use, land use change and forestry (LULUCF) sector.[353]
- Reach good ecological and chemical status in surface waters and good chemical and quantitative status in groundwater by 2027.[354]
- Reduce nutrient losses by at least 50%, the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030.[355,356]
- Significant progress has been made in the remediation of contaminated sites.[357]

For 2050

- Reach no net land take.[358,359]
- Soil pollution should be reduced to levels no longer considered harmful to human health and natural ecosystems and respect the boundaries our planet can cope with, thus creating a toxic-free environment.[360]

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[350] Communication: EU Soil Strategy for 2030 Reaping the benefits of healthy soils for people, food, nature and climate COM/2021/699 final https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0699
[351] United Nations (2015), Transforming our world: the 2030 Agenda for Sustainable Development.
[352] EU Biodiversity Strategy for 2030, COM(2020)380.
[353] LULUCF Regulation (2023) 839.
[354] Water Framework Directive 2000/60/EC
[355] EU Farm to Fork Strategy, COM(2020) 381.
[356] https://euc-word-edit.officeapps.live.com/we/wordeditorframe.aspx?ui=en-us&rs=en-IE&wopisrc=https://eceuropaeu.sharepoint.com/teams/GRP-ENV.D1-SHLIA/_vti_bin/wopi.ashx/files/5ecb2aead0de4f3da4a2dd454593c1ef&wdenableroaming=1&mscc=1&hid=e26f3fb8-de77-4cbb-b88b-52a5e6df193b.0&uih=teams&uiembed=1&jsapi=1&jsapiver=v2&corrid=6dd35150-15f3-48ab-8ec5-27cb63e018b4&usid=6dd35150-15f3-48ab-8ec5-27cb63e018b4&newsession=1&sftc=1&uihit=UnifiedUiHostTeams&muv=v1&accloop=1&sdr=6&scnd=1&sat=1&rat=1&sams=1&mtf=1&sfp=1&halh=1&hch=1&hmh=1&hsh=1&hwfh=1&hsth=1&sih=1&unh=1&onw=1&dchat=1&sc={"pmo":"https://www.office.com","pmshare":true}&wdlcid=en-us&ctp=LeastProtected&rct=Medium&wdorigin=TEAMS.UNIFIEDUIHOST.REBOOT&wdhostclicktime=1666859641078&wdprevioussession=ee925baa-c444-4125-bd1b-8477991c3821&instantedit=1&wopicomplete=1&wdredirectionreason=Unified_SingleFlush.
[357] EU Biodiversity Strategy for 2030, COM(2020)380.
[358] Roadmap to a Resource Efficient Europe, COM/2011/0571.
[359] 7th EU Environment Action Programme, Decision No 1386/2013/EU.
[360] Pathway to a Healthy Planet for All, EU Action Plan: ‘Towards Zero Pollution for Air, Water and Soil’, COM(2021)400.

- Achieve a climate-neutral Europe[361] and, as the first step, aim to achieve land-based climate neutrality in the EU by 2035.[362]
- Achieve for EU a climate-resilient society, fully adapted to the unavoidable impacts of climate change by 2050.[363]

The Soil Strategy also puts forward a definition of healthy soil. Soils are healthy when they are in good chemical, biological and physical condition, and thus able to continuously provide as many of the following ecosystem services as possible:

- provide food and biomass production, including in agriculture and forestry;
- absorb, store and filter water and transform nutrients and substances, thus protecting groundwater bodies;
- provide the basis for life and biodiversity, including habitats, species and genes;
- act as a carbon reservoir;
- provide a physical platform and cultural services for humans and their activities;
- act as a source of raw materials;
- constitute an archive of geological, geomorphological and archaeological heritage.

There is a big variety of soils in the EU, but also many commonalities. The Soil Strategy proposes to define common ranges or thresholds beyond which soils cannot be considered healthy anymore. Such indicators for soil health and their range of values that should be achieved by 2050 to ensure good soil health should be developed and agreed, and they should be considered at EU level in the context of the Soil Health Law to ensure a level playing field and a high level of environmental and health protection.

The following **non-binding policy initiatives under the EU Soils Strategy** have been considered. Table 3-1 provides an overview of non-binding measures foreseen in the EU Soil Strategy for 2030 and their expected impacts on the baseline scenario.

Table 3-1: Overview of the predicted impact of non-binding measures foreseen in the EU Soil Strategy for 2030 on the baseline scenario

Measure	Level of support	Short explanation
Contribution to the assessment of the state of peatlands in the context of the Global Peatlands Initiative hosted by FAO and UNEP	Low	• Contributing to the assessment allows for better informed decision making, e.g. in policy making. However, this is a step further and still needs to be done following the assessment of the state of the art; • Peatlands is a specific regional focus that does not apply to all MS.
Joining the international initiative '4 per 1000' to increase the soil carbon in agricultural land;	Medium	• The Initiative recommends tools and time lines, however lacks a definition of targets for health soils. Actions following the Initiative is thus vague; • Additionally it is a voluntary Initiative.
Communication on restoring sustainable carbon cycles;	Low	• Improved communication can better inform the development of the EU's long-term vision for sustainable carbon cycles; • However, measuring soil carbon is time and labour-intense[364] and, thus, unlikely to be feasible for small holders. • Additionally, the initiative aims to enable a carbon-neutral EU whereas the goal of healthy soils (acting as a net carbpn sink[365]) could be preferable.

[361] Climate Law Regulation (EU) 2021/1119.
[362] LULUCF Regulation 2023/839 .
[363] EU Climate Adaptation Strategy, COM/2021/82.
[364] Zyngier (2021). Soil carbon: A source or a sink in the net zero challenge?

Measure	Level of support	Short explanation
Investigation on the streams of excavated soils generated, treated and reused in the EU;	Medium	• Increasing circularity of excavated soils can reduce the demand for primary resources in the construction sector, e.g..[366] Thus, the amount of excavated soils could potentially be reduced.
Guidance to public authorities and private companies on how to reduce soil sealing, including best practices for locally driven initiatives for de-sealing artificial surfaces;	High	• Guidance on the implementation of strategies and available means increases their accessibility for actors on the ground and, thus, large scale implementation.
Exchange of best practices on spatial planning systems which successfully address the challenge of land take;	High	• Knowledge sharing on spatial planning might become important, i.e. globally facing urban sprawl.
Publication of the first assessment of EU soil biodiversity and antimicrobial resistance genes in agricultural soils;	Low	• This publication might contribute to awareness raising. However, to have a positive impact in the long-term, its finding must be translated into guidelines and shared with relevant stakeholders.
Assessment of the risk of further alien flatworm species for their potential inclusion in the list of 'invasive alien species of Union concern';	Medium	• Invasive alien flatworms are yet under-researched, despite frequently having negative impacts on soil biodiversity and agricultural yields.[367]
Strive for a post-2020 global biodiversity framework that recognises the importance of soil biodiversity;	High	• The CBD can be considered as guiding for global policy making on biodiversity. In its post-2020 framework, soil should be included as one of the areas of interest to raise global awareness.
Active contribution to the adoption by the 15th Conference of the Parties to the Convention on Biological Diversity of the plan of action 2020-2030 for the International Initiative for the Conservation and Sustainable Use of Soil;	High	• So far, the contribution to the review of the International Initiative for the Conservation and Sustainable Use of Soil Biodiversity was rather low.[368] Increasing contribution can reduce the lack of information hampering a better implementation of soil biodiversity management strategies.
Support to the establishment of the Global Soil Biodiversity Observatory as proposed by the Food and Agricultural Organisation's (FAO) Global Soil Partnership;	Medium	• Establishing an international hub for soil biodiversity can increase knowledge and international collaboration.
Preparation of a set of 'sustainable soil management' practices;	Low	• Needs to increases the sustainability of soil are case-dependent and thus demand tailored means. It could be more beneficial to share practical experiences and make them publicly accessible.
Assistance to Member States to put in place through national funds the 'TEST YOUR SOIL FOR FREE' initiative;	High	• Due to the high labour and time costs for assessing the soil quality, support (including economic support in kind) for famrers and other actors is needed.
Creation of a network of excellence of practitioners on Sustainable Soil Management;	Low	• It might be preferrable to contribute to already existing initiatives and networks to increase their quality (Such as the global soil biodiversity observatory GLOSOB promoted by the FAO[369]).
Dissemination of successful sustainable soil and nutrient management solutions;	Medium	• The dissemeination must include contextual background information to increase their usefulness. Additionally, support for implementation is needed.
Promotion of Sustainable Soil Management through voluntary commitments between actors in the food system and the European Land Owners Soil Award;	Low	• Voluntary commitments can bring benefits. However, consistent reporting, monitoring and review systems are needed.[370]
Support to the Global Soil Partnership in promoting sustainable soil management worldwide;	Medium	• Global commitment is needed to improve soil health in the long-term. However, focus on the European circumstances is needed for successful implementation.
Establishment of a methodology and relevant indicators, starting with the UNCCD's three indicators, to assess the extent of desertification and land degradation in the EU;	High	• Uniformed indicators are necessary to enable monitoring, reporting and reviewing of strategies.
Publication of information every five years about the state of land degradation and desertification in the EU;	High	• This can inform the assessment of applied strategies and rise awareness among society.
Continued support to key initiatives such as the Great Green Wall initiative, Regreening Africa, and aid on land/soil	High	• Initiatives with holistically positive impacts should be further supported, also to ensure supply with agricultural products, e.g.

[365] E.g. Liu et al. (2022). Carbon-based strategy enables sustainable remediation of paddy soils in harmony with carbon neutrality.
[366] Hale et al. (2021). The reuse of excavated soils from construction and demolition projects: Limitations and possibilities.
[367] Murchie and Justine (2021). The threat posed by invasive alien flatworms to EU agriculture and the potential for phytosanitary measures to prevent importation.
[368] UNEP (2020). Review of the international initiative for the conservation and sustainable use of soil biodiversity and updated plan of action.
[369] https://www.fao.org/global-soil-partnership/resources/events/detail/en/c/1468774/
[370] Neumann and Unger (2019). From voluntary commitments to ocean sustainability.

Measure	Level of support	Short explanation
issues in development cooperation;		
Dialogue and knowledge exchange on the risk assessment methodologies for soil contamination;	Medium	• Allows the development of indicators
Development of an EU priority list for contaminants of major and/or emerging concern that pose significant risks for European soil quality;	Medium	• Knowledge about this allows for derived policy-making
Development of the European Soil Observatory (EUSO) and of the Land Information System for Europe (LISE);	Medium	• Multinational organisations can contribute to the improvement of EU soil health. However, already existing networks should be considered.
Funding of the 'Horizon Europe' Mission 'A Soil Deal for Europe';	High	• This can contribute to both improving soil health and the achievement of the EGD.
Launch of a soil literacy engagement and awareness initiative;	Medium	• This can have positive impact when combined with funding for the 'TEST YOUR SOIL FOR FREE' initiative, e.g.
Comprehensive portfolio of actions for communication, education, and citizen engagement on soil health.	Low	• This might have only limited impact on improving soil health but could be included in initiatives, e.g. for best-practice sharing.

As to specifying the exact anticipated impacts, the effect of the above listed soft measures is challenging to anticipate. In most cases, the impact of each measure depends on its (effective) implementation. Generally speaking, when properly implemented information sharing generally results in a number of benefits, for example cost reduction, improved transparency, improved trust between governments and industry/citizens, improved communication between different tiers of government or (to some extent) convergence in practices across Member States.[371] Nevertheless, as stated in the Soil Strategy, the example of the Soil Thematic Strategy has shown that voluntary actions alone - without the soil legislation – is not sufficient to stop and revert soil degradation.

4 Other Green deal initiatives: the Biodiversity Strategy and the Farm to Fork Strategy

Within the framework of the EU Green Deal, the Biodiversity Strategy[372] and the Farm to Fork Strategy,[373] a set of common objectives of reducing nutrient emissions to the environment by at least 50% by 2030, a reduction in the use of fertilisers by 20% by 2030 and a reduction in the use of pesticide by 50% by 2030 are established. These nonbinding targets seek to simultaneously ensure that soil fertility does not deteriorate. Measures mentioned include a better implementation and enforcement of environmental legislation as well as applying balanced fertilisation and sustainable nutrient management

The Mission 'A Soil Deal for Europe' and the EU Soil Observatory

EU Missions are a novelty of the Horizon Europe research and innovation programme for the years 2021-2027. EU Missions are a new way to bring concrete solutions to some of the EU greatest challenges. They have ambitious goals and will deliver tangible results by 2030. They will deliver impact by putting research and innovation into a new role, combined with new forms of governance and collaboration, as well as by engaging citizens.

[371] See https://collections.unu.edu/eserv/UNU:2958/JCST-Aug12-1.pdf
[372] Communication from the Commission - EU Biodiversity Strategy for 2030 - Bringing nature back into our lives, COM/2020/380 final https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1590574123338&uri=CELEX:52020DC0380
[373] Communication from the Commission - A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system, COM/2020/381 final https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0381

One of the EU missions is the Mission 'A Soil Deal for Europe'

The main goal of the Mission 'A Soil Deal for Europe' is to establish 100 living labs and lighthouses to lead the transition towards healthy soils by 2030.

The Mission has the following 8 objectives
- reduce desertification
- conserve soil organic carbon stocks
- stop soil sealing and increase re-use of urban soils
- reduce soil pollution and enhance restoration
- prevent erosion
- improve soil structure to enhance soil biodiversity
- reduce the EU global footprint on soils
- improve soil literacy in society

The Mission will support the EU's ambition to lead on global commitments, notably the Sustainable Development Goals (SDGs), and contribute to the European Green Deal targets on sustainable farming, climate resilience, biodiversity and zero-pollution. It is also a flagship initiative of the long-term vision for rural areas.

The EU Soil Observatory

The EU Soil Observatory (EUSO) was launched by the JRC in December 2020 in response to the increasing policy interest in soils under the umbrella of the European Green Deal objectives. These include reducing land degradation, mitigating climate change, halting biodiversity loss or achieving a pollution free environment.

Since its creation, the EU Soil Observatory finds itself anchored into a strengthened policy context and a growing attention on the need to protect and enhance soil health. EUSO is expected to play in important role in this new context, to help support and inform the policy agenda on soil, interact with the research activities and raise the public's awareness of the need for soil protection.

Objectives and functions of the EU Soil Observatory

Vision
The EU Soil Observatory (EUSO) will become the principal provider of reference data and knowledge at EU-level for all matters relating to soil.

Mission
The EU Soil Observatory aims to be a dynamic and inclusive platform that supports EU soil-related policymaking. The EUSO will provide the relevant Commission Services, together with the broader soil user community, with the knowledge and data flows needed to safeguard and restore soils.

The EUSO will both support, and benefit from, EU Research & Innovation on soils while raising societal awareness of the value and importance of soils to the lives of citizens.

The EUSO will closely collaborate with relevant EU Agencies (e.g. EEA, EFSA, ECA) and Horizon Europe's Soil Mission.

Ultimately, the EUSO will support EU policies by ensuring that the Commission is able to fully capitalise on the information made available through integrated data flows by transitioning from simply monitoring to understanding. In this manner, the EUSO will support the implementation of the Soil Strategy and other soil-related objectives of the European Green Deal.

To realise this vision and mission, the EUSO carries out a range of functions, which in turn, support the implementation of the EU Soil Strategy 2030. Each function is underpinned by relevant services and tools.

Figure 4-1: Main functions of the EU Soil Observatory

The six main functions of the EU Soil Observatory are to:

1. In line with the JRC’s role as the Commission's science and knowledge service, the EUSO will support the generation of independent scientific evidence, advice and knowledge for soil-related policies.

2. Support the development of an operational EU-wide Soil Monitoring System: the EUSO supports the development of a harmonised soil monitoring system for the EU by integrating the current LUCAS Soil programme with national or regional soil monitoring activities. An important element is the close networking with the EU Member States, relevant Commission services and agencies. The eventual integrated monitoring system should contribute to indicators that reflect policy targets (e.g. SOC MVR, Soil Pollution Watch List, biodiversity, erosion, etc.). In addition to the practical considerations of sampling design for the monitoring network (geographical location, the parameters that are measured, both qualitatively and quantitatively), a shared data infrastructure (to collect, transmit, share, disseminate soil monitoring data) will be developed, based on INSPIRE principles, that integrates pan-European national reporting obligations (also CAP Strategic Plans, Sustainable Use of Pesticides, Nitrates Directive, LULUCF) and

regional initiatives (e.g. Alpine Convention, devolved responsibility for soil protection). Through the implementation of the EU Soil Strategy and the work programme of the Mission "A Soil Deal for Europe", the EUSO will support Member States in establishing and operating national or regional monitoring systems to support the exchange of harmonized information about the state of soils (indicators), to be integrated at EU level. Outcomes of soil monitoring will flow to the European Soil Data Centre (ESDAC).

3. Further consolidate and enhance the capacity and functionality of the current European Soil Data Centre (ESDAC): as the core of the EUSO in terms of managing data flows (both inputs and outputs), ESDAC will be consolidated and enhanced in terms of the capacity and functionality to support evolving knowledge needs. Consideration will be given to innovative data streams.

4. Establish an EU Soil Dashboard that reflects the state of soil health and trends in pressures affecting soil health: the EUSO is working on the development of a novel dashboard that reflects both the state and trends in pressures affecting soil health. Key policy messages will be developed through indicators that are populated by a range of data flows (e.g. monitoring, modelling, Copernicus, citizen science, big data, etc.). Some indicators will be provided by key stakeholders. The EUSO will assess and indicate the scientific robustness of indicators. Indicator development, together with policy thresholds, will evolve according to scientific developments (e.g. Horizon Europe projects). Additional elements will be developed to reflect the implementation of specific policy targets (e.g. Soil Strategy Action List, Clean Soil Monitoring and Outlook, Biodiversity Strategy, Soil Mission, SDGs, etc.). The EU Soil Dashboard will be closely linked to data flows to ESDAC.

5. Support research and innovation through the implementation of Horizon Europe's Mission "A Soil Deal for Europe": an integral part of the Horizon Europe framework programme for 2021-27 is the concept of Missions. These are targeted and integrated commitments to solve some of the greatest societal challenges. The EUSO aims to be a key component in the implementation of the "Soil Deal for Europe" Mission as well as the beneficiary of several outcomes. Specifically, the Mission funds a series of R&I Actions to support the EU's path to sustainable and regenerative soil management as part of the wider green transition in both urban and rural areas. The EUSO is supporting research calls developed under the evolving work programme of the Mission and will become a beneficiary of the knowledge produced by EU-funded research actions. A dedicated corner in the EUSO Portal will be established to host R&I outcomes. Specifically, the EUSO will coordinate the monitoring elements of the Mission.

6. Provide an open and inclusive EUSO forum that supports the drive towards a societal change in the perception of soil. The EUSO Forum is the principal focus for the EU Soil Observatory with regards to stakeholder engagement. Conceptually, the EUSO Forum is a multi-channel entity that uses a mix of participation methods to ensure a two-way dialogue between the Observatory and its user base. The Forum provides a) mechanisms to inform the EUSO stakeholder community of developments, b) support enhanced soil literacy and c) collect feedback on the operation of the Observatory. The Forum builds on the current operational solutions developed under ESDAC, which include access to a wide range of online resources, widely read newsletters and an active data helpdesk. New tools will provide clear messaging on how the European Green Deal will change the state of soil health across the EU (Dashboard, annual bulletins, etc.). Face-to-face dialogue on key issues has been established through Technical Working

Groups and via a dedicated annual hybrid workshop, the EUSO Stakeholder Forum. Close links are being maintained with the European Soil Partnership (ESP) and key research networks (e.g. EJP SOIL, SoilBON, ENSA, ELSA). With the support of the "A Soil Deal for Europe" Mission, the EUSO will look to develop an outlet for a coalition on Soil Literacy that aims to connect diverse organisations, projects and people that contribute to soil literacy and the sustainable use and management of soils.

5 MEMBER STATE LEGISLATION

Existing Member State legislation has been analysed in 2017 in the frame of a study carried out by Ecologic study and funded by the Commission through a service contract.[374]

The analysis showed that only a limited number of Member States have in place explicit, overarching policies for soil protection for example Germany and Italy which both have in place Soil Protection Acts. In some Member States, for example Austria, a regional approach to soil management is undertaken. In Austria there is no national soil protection law as this is regulated by soil protection laws of the federal states. While some federal states have very extensive soil protection legislation or non-binding soil-focused instruments, there is no soil protection legislation in some other federal states.

According to the study, in the majority of instances the coverage of the national legal instruments is partial. For example, there may be no policy in place to address the entire picture of soil protection; however, policies may be in place to address specific land uses and their impact on soils, commonly agricultural or forestry soils. For example, this is the case in Lithuania (Law on Land), Hungary (Act on Cultivated Land), Poland (the Act on Protection of Agricultural and Forest Land) and Slovakia (Act No. 220/2004 Coll. Concerning the Protection and Use of Agricultural Soil). These Member States have in place instruments focused on agricultural soils explicitly and coordinating action in an overarching manner.

In contrast, a number of different policies are in place focusing on environmental protection at a high level. Depending on how exactly these are defined and implemented it is possible that these may provide strategic coverage of soil issues. sustainable use of land and water with the goal of developing a long term plan for sustainable land use.

The main legal acts appearing in the inventory have been analysed for the purpose of this Impact assessment to determine whether they may have a direct or indirect contribution to soil protection. This analysis has been carried out for each of the aspects of soil degradation.

However, it has not be possible to quantity to which extent the national legislation contributes to address the issues. As a matter of fact, and as demonstrated in this Impact assessment, all Member States are faced with soil degradations which means that the national legislation, in absence of a dedicated EU legislation, has not been able to address the problems. For example, while it appears that a large majority of Member States has

[374] Inventory and Assessment of Soil Protection Policy Instruments in EU Member States (Ecologic Institute, 2017) (1).pdf and the wiki https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?spaceKey=SOIL&title=Home

legislation on soil contamination, it is estimated that there are still around 2,8 million of potentially contaminated sites in Europe.

Similar findings can be found in the conclusions from 2020 of an enquiry committee of the French Senate which stated that, “there is no integrated approach in (…) soil protection law. This results in a lack of clarity on the chain of responsibility for preventing pollution and repairing damage and potential blind spots”[375] or in the German reflection paper on key points for a reform of national soil protection law which fond that “ t soil protection is a cross-cutting task which touches on various areas of the law; however, these areas are, for the most part, not harmonised with soil protection requirements.”[376]

It appears from the analysis, that on the one hand the approaches vary from one Member State to another and on the other hand that some degradations aspects are better covered than others:

- differences amongst Member States: a few Member States have dedicated legislative acts on soils while in the other Member States soil may benefit indirectly from other legislation. As an example, the Soil Act in Bulgaria focuses on the prevention of soil degradation and damages, the lasting protection of soil functions and the restoration of damaged soil functions. In France on the contrary, provisions on soils are dispersed in various legislative acts such as laws concerning urban planning, biodiversity, or climate.
- differences concerning the aspects of soil degradation: as mentioned above, soil contamination appears as the soil degradation aspect that is best covered by existing national legislation. In many Member States the national legislation contributes directly or indirectly to address loss of soil organic carbon, soil erosion, loss of soil biodiversity and sealing of soil. On the contrary, in a large majority of Member States there is no or little contribution from national legislation to address soil salinization, excess of nutrients in soils, soil acidification and water retention capacity.

The differences are presented visually in a very simplified format in the following table. The table is not exhaustive and does not necessarily present the current legal situation in each of the MS. It represents only a very simplified overview of the selected information retrieved from the specific national legislation indicated in the above mentioned wiki.

[375] http://www.senat.fr/rap/r19-700-1/r19-700-1_mono.html#toc3

[376] Eckpunkte für eine Novelle des nationalen Bodenschutzrechts https://www.bmuv.de/fileadmin/Daten_BMU/Download_PDF/Bodenschutz/eckpunktepapier_novelle_bodenschutzrecht_en_bf.pdf

Table 5-1: visual representation of the existing national legislation

		AT	BE	BG	CY	CZ	DK	DE	GR	ES	EE	FI	FR	HR	HU	IR	IT	LV	LT	LU	MT	NL	PL	PT	RO	SK	SL	SE
Nutrient loss/ excess of nutrients in soil	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
Loss of/ low soil organic Carbone (SOC)	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
Soil Erosion (by water or wind)	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
Soil compaction	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
Soil acidification	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											

Salinisation	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
Water retention capacity	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
Loss of soil biodiversity	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
Soil sealing/land take	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
Prevention of soil contamination	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
Remediation of soil contamination	Agricultural																											
	Forestry																											
	Urban																											
	Industrial																											
		AT	BE	BG	CY	CZ	DK	DE	GR	ES	EE	FI	FR	HR	HU	IR	IT	LV	LT	LU	MT	NL	PL	PT	RO	SK	SL	SE

	Direct contribution to soil protection
	Indirect contribution to soil protection
	No or very minor contribution to soil protection
	No data available

The acts that have been taken into consideration for the purpose of this table are the following :

AT:

- Law on the Remediation of Contaminated Sites
- Federal Forest Law
- Environmental Impact Assessment Act 2000
- Soil protection law are regulated by soil protection laws of the federal states, not the national level

BE:

- (Flanders) — Decree on soil remediation and soil protection
- (Flanders) – Decision of the Flemish Government on Erosion Control
- (Flanders) – Decree on Environmental Damage and Decision on Environmental Damage
- (Flanders) – Flemish Spatial Planning Code
- (Brussels) – Ordinance on Environmental Permits
- (Brussels) — Ordinance on the management and clean-up of soils
- (Brussels) — Decree on soil remediation and soil management
- Brussels) – Brussels Spatial Planning Code
- (Wallonia) — Decree on the management and remediation of soils
- (Wallonia) – Territorial Development Code
- (Wallonia) – Agricultural Code
- (Wallonia) – Environment Code

BG:

- Regulation No. 26 for Reclamation of Damaged Terrains, Improvement of Low Productive Soils, Removal and Utilization of the Humus Layer
- Soil Act
- Law for Preservation of the Agricultural Lands

CY:

- The Water Pollution Control Law of 2002
- Forest Law

To be noted that there is a substantial lack of information for this country

CZ:

- Czech Act Concerning the Protection of Agricultural Soil
- Act Concerning the Protection of Agricultural Soil
- Forestry Act

DK:

- Act on Management of Agricultural Land
- Act on Soil Contamination
- Act on Forest
- Act on Agricultural Use of Fertilizers and on Plant Cover
- Nature Protection Act

DE:

- Act on Protection against Harmful Soil Changes and on the Remediation of Contaminated Sites
- Building Code
- Law on Nature Conservation and Landscape Management
- Federal Soil Protection and Contaminated Sites Ordinance

GR:

- Decision on the Use in Agriculture of Sludge from the Treatment of Household and Urban Wastewater
- Law for the Protection of the Environment
- Law on Conservation of Biodiversity
- Law on Sustainable Urban Planning
- National Action Plan for Combating Desertification

ES:

- Decree Regulating the Use of Sewage Sludge in the Agricultural Sector
- Royal Decree 9/2005 establishing activities that are potentially soil polluting and criteria to declare soils as polluted
- Law on Waste and Polluted Soils
- Decree on the Forestation of Agricultural Plots of Land
- Decree on a Sustainable Use of Fitosanitary Products

EE:

- Fertilisers Act
- Definition of Valuable Agricultural Land (Rural Development and Market Regulation Act)
- Earth's Crust Act
- Planning Act
- Environmental Liability Act
- Land Improvement Act

FI:

- Decree on the Assessment of Soil Contamination and Remediation Needs
- Fertiliser Products Act, Decree of the Ministry of agriculture and forestry on fertilizer product
- State Aid for Financing of Basic Drainage
- Environmental Protection Act
- Forest Act

- Nature Conservation Act

FR:

- Law for access to housing and renewed urban planning
- Law for recapturing biodiversity, nature and landscape
- Climate and resilience law
- Environmental code
- Forestry code
- Law for the future of agriculture, food and forest

HR:

- Ordinance on the Protection of Agricultural Land against Pollution
- Ordinance on the Methodology for Monitoring the State of the Agricultural Land
- Agriculture Land Act
- Forestry Act
- The Nature Protection Law

HU:

- Ministerial Decree on Preparation of Soil Protection Plan
- Act on the Protection of Cultivated Soil
- Rules about Agricultural Utilization of Sewage Sludge and Waste Water
- Act on the Formation and Protection of the Built Environment
- Decree on rules concerning the screening surveys of remedial site investigation

IR:

- Historic Mine Sites – Inventory, Risk Classification and Remediation
- Environmental Protection Agency Act
- Forestry Act

IT:

- Protocol of Soil Conservation of the Alpine Convention
- Land Take and Soil Sealing Regulations
- Decree on the Sustainable Use of Pesticides
- Environmental Code

LV:

- Law on Amelioration
- Regulation on Soil and Subsoil Quality Standards
- Regulation Regarding Waste Landfills and Waste Dumps
- Law on Forests
- Law on Pollution

LT:

- Law on Land
- State Control Regulation on Land Use
- Environmental Protection Law
- Law on Forests

LU:

- Law on the Management of Waste
- Grand Ducal Regulation of 23 December 2014 on Sewage Sludge
- Law on the Protection of Nature and Natural Resources

MT:

- Environment Protection Act
- Development Planning Act
- Fertile Soil (Preservation) Act

NL:

- Infiltration Decree on Soil Protection
- Erosion Regulation
- Fertilizer Act and Delegated Legislation
- Soil Protection Act

PL:

- Act on Protection of Agricultural and Forest Land
- Environmental Protection Law
- Prevention and remediation of environmental damage. (
- Act on Forests
- Regulation of the Minister of Agriculture and Rural Development of 18 June 2008 on the implementation of certain provisions of the Act on fertilizers and fertilization

PT:

- Management of Waste from Extractive Industries Legal Regime
- Legal Regime for Territorial Management Instruments
- National Agriculture Soils Protection Law
- Framework Act of Land Use, Spatial Planning and Urbanism Public Policy

RO:

- Law on Land Reclamation
- Law on Afforestation of Degraded Land
- Decree on Remediation
- Ordinance on Environmental Protection

SK:

- Act Concerning the Application of Sewage Sludge and Ground Sediments into the Soil
- Soil Protection Act

- Act Concerning Prevention and Rectification of Environmental Damage

SL:

- Agricultural Land Act
- Decree on the Management of Sewage Sludge from Urban Waste Treatment Plants
- Environmental Protection Act

SE:

- Regulation on compensation for contamination damage and state aid for remedial
- The Swedish Environmental Code

Examples of national instruments and brief description

Out of all the Member State legislations, several national instruments have been identified as highly relevant (with a high level of soil protection), such as the German Federal Soil Protection Act, the Agricultural Code of Wallonia, the Soil Protection Act of Slovakia, Soil Protection Act and the Soil Quality Decree and Regulation of the Netherlands and the Soil Act of Bulgaria.

The German instrument, however, remains the most ambitious and relevant instrument, given its scope and objectives being the most aligned with those anticipated for the Soil Health Law, also in light of its planned revision (see below).

German Federal Soil Protection Act

The Act aims to **protect or restore soil functions**. Actions include prevention of harmful changes to the soil, rehabilitation of the soil, of contaminated sites and of waters contaminated by such sites; and precautions against negative impacts on soils. Where soils are affected, disruptions of their functions should be avoided as far as possible. The Act focuses on **contamination and sealing, and on rehabilitation of contaminated sites**. For the protection of soil fertility and functions, the Act sets out **principles of good practices for agricultural practices**, for example that the soil shall be worked in a manner that is appropriate for the relevant site, taking weather conditions into account, soil structure shall be conserved or improved, and soil compaction avoided as far as possible.

The Act provides a comprehensive and specific legal framework to manage soil contamination issues. The specific soil threats that are explicitly mentioned within the text are, for example, erosion by wind and/or water, compaction or soil sealing. The soil functions that the Act aims to protect and restore are, for example, biodiversity, raw materials, soil as a filter of nutrients or human activity.

With regards to the objectives and projected impacts of the Act, it is an ambitious instrument with relevant objectives. Namely, the aim of the Act is to secure or restore soil functions, in a sustainable manner. Negative effects on soil must be avoided, and such negative effects on soils must be rehabilitated. In addition, precautionary measures must also be taken. The Act is currently ongoing a revision and a number of modifications are being considered, for example mandatory sustainable agricultural practices, strengthening of the precautionary aspect (e.g., on erosion, compaction), soil protection areas, reduction of soil sealing, protection of the soil biodiversity or strengthening of natural soil functions.

Agricultural Code of Wallonia, Belgium

The Agricultural Code aims to organise a **common vision for agriculture and its role in the Walloon society**, whereas previously agriculture was scattered within several legal bases. The Code provides bases for orientation of policies, legislation and subsidies to support this vision, and facilitates the understanding of diverse regulations on agriculture by grouping them all in one unique Code.

Soil is directly mentioned as a natural resource to protect and manage, the maintenance of agricultural land and the contribution to decrease the pressure and land speculation are cited as objectives, a specific section dedicated to erosion and flooding mitigation is defined, land consolidation operations include soil classification according to their crop production ability, and a section dedicated to agricultural land policy (management, observatory, expropriation, subsidies) is included.

Despite its relevance for soil protection, the anticipated impacts for the purpose of the Soil Health Law have been assessed as somewhat limited. The scope of the Code is restricted to agricultural soil and as such, the objectives are mainly focused on improve agricultural conditions, agriculture that respects environment and biodiversity and to improve the economic situation of our farmers and ensure their future.

Soil Protection Act, Slovakia

The Soil Protection Act (in its full name Protection and Use of Agricultural Soil) **aims to protect the characteristics and functions of the agricultural soil**. It also includes **provisions for a sustainable use of agricultural soils**. The owner/tenant of agricultural soil has an obligation to address various soil threats (e.g., physical-chemical degradation and contamination). The Act also prescribes the rules for the changing of the land from agricultural to non-agricultural land (i.e., land take). It is of national territorial coverage. It explicitly addresses a number soil threats, namely erosion by water and wind, contamination, compaction, and loss of soil organic matter. It also (implicitly) addresses loss of soil biodiversity and salinisation.

Similarly to the instrument of Wallonia, the anticipated impacts of the Slovak Act for the purpose of the Soil Health Law have been assessed as limited as the scope of the Act remains restricted to agricultural soil only.

Soil Protection Act and the Soil Quality Decree and Regulation of the Netherlands

The Soil Protection Act aims to prevent, limit and/or reverse changes in the soil quality, that diminishes or threatens the functional properties of the soil and groundwater for people, plants and animals. The Act regulates the protection of soil through limitations on the application of waste, contaminated water or sludge on or in the soil and the burial of human remains (including ashes) with a view to leaving them there.

The Soil Quality Decree and Regulation focuses on sustainable use of soil in relation to three topics: environmentally safe use of building materials, management of (slightly) polluted sites and the quality of the actual activities carried out. It aims to strike a balance between protection of soil and its use for economic and social purposes.

For the purposes of the Soil Health Law initiative, the scope of the instruments applied in the Netherlands is rather limited. While the scope includes all soils (not only agricultural), the Act focuses on limiting impacts of waste, contaminated water, sludge, etc. only, and the Decree and Regulation place their focus on the relationship between use of soil and infrastructure.

Soil Act of Bulgaria

The Soil Act focuses on the prevention of soil degradation and damages, the lasting protection of soil functions and the restoration of damaged soil functions. Soil protection, use and restoration shall be based on the following principles:

- Ecosystem and comprehensive approach;
- Sustainable use of soils;
- Priority of preventive control to forestall or limit soil degradation and damage to soil functions;

- Applying good practices in soil use;
- Polluter pays principle for the damage caused; and
- Public awareness of the environmental and economic benefits of soil protection from degradation and of measures to preserve soil.

Next to the German Federal Soil Act, the Bulgarian instrument is another very comprehensive instrument. Its scope is not limited to agricultural soils as is the case with some other national instruments and the initiative is directly linked to the EU Soil Thematic Strategy. As such, for the purposes for the Soil Health Law initiative the Bulgarian instrument can also be considered rather relevant with likely tangible impacts.

Conclusion

Existing EU policies make positive contributions to the improvement of soil health but will not be sufficient to achieve the vision of the Soil Strategy to have all soils healthy by 2050 because they do not comprehensively address all the drivers of soil degradation and therefore significant gaps remain as explained in detail in chapter 2 and annex 6. Existing policies at EU and MS levels have not been able to prevent that 60-70% of soils in the EU are not healthy and that soil health is still deteriorating in the EU.

Despite recently proposed initiatives on the NRL, revision of the LULUCF regulation and on carbon removal as well as the new CAP which will positively contribute to maintain or restore the soil health on some aspects, a large gap at EU and MS level will remain.

6 EVOLUTION OF PROBLEM IN ABSENCE OF EU INTERVENTION

In the following section, an overview of the identified problem areas to soil health in the EU are presented.

6.1 Socio-economic developments

For the period to 2030 no major changes in demographic trends are foreseen compared to today. Population growth is slowing, but the EU population is still expected to grow to 2030 and likely to 2050, after which it will gradually shrink. Further ageing and depopulation will continue to impact rural areas across the EU, while urban areas are expected to continue to see new population growth. The share of the population living in cities is expected to grow in Europe from approximately 75% in 2018[377] to nearly 84% by 2050.[378] Due to this continued urbanisation, land take and soil sealing may continue locally around urban centres, even as the total EU population is not significantly growing. Notably, many urban dwellers tend to favour homes with small personal outdoor spaces (and especially gardens), which contributes to urban sprawl, and therefore to land take. The Covid-19 has exacerbated this desire for an outdoor space in their homes and for good quality housing in general, a trend which is likely to continue in the

[377] EIB (2018) The Story of Your City: Europe and its Urban Development, 1970 to 2020. Available at: https://www.eib.org/en/essays/the-story-of-your-city#:~:text=Today%2C%2072%25%20of%20the%20EU,Italy%2C%20Netherlands%2C%20UK).

[378] UN Department of Economic and Social Affairs (2018) 2018 Revision of World Urbanization Prospects. Available at: https://population.un.org/wup/

future.[379] This creates a particular challenge for any legislation aiming at limiting land take and land sealing, which may need to be complemented by national legislation aiming at increasing the population density of already settled areas, rather than allowing the settled areas to expand indefinitely.

6.2 Evolution of the main problem: Erosion

The study by Panagos et al. (2015)[380] projects that total soil loss due to water erosion rate will be (absolute value) of 595 million T by 2050 under the RCP 4.5 scenario. This is largely due to the impacts of the changing climate – particularly felt through shifting hydrological conditions caused by changing weather patterns. Depending on the Representative concentration Pathway (RCP), soil loss by water erosion may increase in the range of 13-25.5% by 2050 compared to the 2016 baseline. An additional study by Panagos et al.,[381] calculated the loss of agricultural productivity due to soil loss due to water erosion at approximately €1.2 billion to the EU-27 annually (reference year 2010).

Regarding wind erosion, the erosion prone area[382] in the EU is calculated at 3.25 million km^2 in 2050, taking into consideration the expected decrease in UAA, and gradual increase in total EU forest area.[383] The study by Borrelli et al. estimates that 0.53 T ha yr^{-1} of soil are lost on average in the arable lands of the EU.[384] However, it is assumed that wind erosion can also impact the 'erosion prone' ecosystems as described by Panagos et al. in the above section. Applying the rate identified above to this land area,[385] it is calculated that soil loss due to wind erosion in the EU-27 erosion prone areas is approximately 16,973 t/y in the baseline year of 2010, expected to increase to 17,206 t/yr in 2050. However, data on the projected impacts of climate change on wind erosion is not available. In most parts of Europe, drought frequency will increase, heavy precipitation events will increase in winter across Europe and in northern Europe in summers too. Longer periods of precipitation shortages will significantly increase the risk of forest fires, also in regions where it has not been a natural feature of local forest ecosystems. These factors are expected to exacerbate soil erosion in the EU.

379 JLL (2020) Housing needs and resident preferences across Europe during Covid-19. Available at: https://residential.jll.co.uk/insights/research/housing-needs-and-resident-preferences-across-europe-during-covid-19

380 Panagos et al.,(2015) The new assessment of soil loss by water erosion in Europe; Panagos et al., (2021). Projections of soil loss by water erosion in Europe by 2050.

381 Panagos et al., (2018). Cost of agricultural productivity loss due to soil erosion in the European Union: From direct cost evaluation approaches to the use of macroeconomic models.

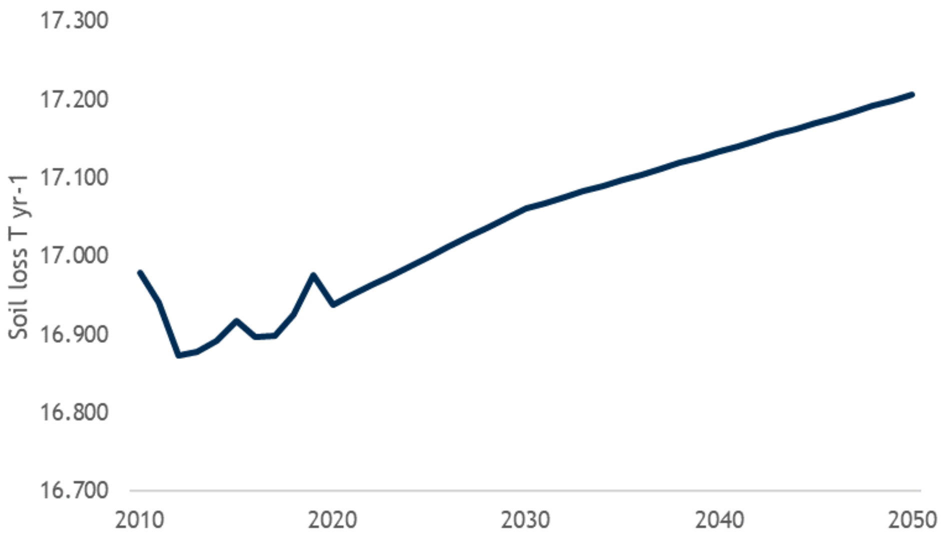
382 Panagos et al.,(2015) The new assessment of soil loss by water erosion in Europe; Panagos et al., (2021). Projections of soil loss by water erosion in Europe by 2050.

383 The EU-27 UAA is projected to shrink by 3.9% by 2050- *Panagos et al., (2021). Projections of soil loss by water erosion in Europe by 2050*, and reach 1,605,00km^2 in 2030- *EC (2021), EU agricultural outlook for markets and income, 2021-2030.* EU forest area is expected to reach 1,614,000 km^2 in 2030- *EC (2021), EU agricultural outlook for markets and income, 2021-2030.* The 2020-2030 forest growth rate is then projected from 2030-2050 (reaching a total EU forest area of 1,695,260km^2 in 2050).

384 Borrelli et al., (2017) A New Assessment of Soil Loss Due to Wind Erosion in European Agricultural Soils Using a Quantitative Spatially Distributed Modelling Approach.

385 Estimated at 3,202,428 km^2 in baseline year. Utilised agricultural area calculated as 1,629,058km^2 in EU 27 (https://ec.europa.eu/eurostat/databrowser/view/tag00025/default/table?lang=), EU-28 forest coverage taken from Maes et al (2020) Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, minus UK estimated coverage of 24,163km^2 (aligning with MAES reporting of CLC areas 311, 312, 313, 324)- taken from Cole et al., (2018) Acceleration and fragmentation of CORINE land cover changes in the United Kingdom from 2006–2012 detected by Copernicus IMAGE2012 satellite data.

Figure 6-1: Projected soil loss due to wind erosion in 'erosion prone' areas within the EU-27 to 2050



Source: Soil loss rate taken from Borrelli et al., (2017) (0.53 T/ ha/ yr),
Note: Climate change impacts not considered due to uncertainty on the quantified impacts on soil wind erosion.

Regarding economic impacts of soil loss, Panagos et al., (2022)[386] estimated that current phosphorus displacement in the EU-27+UK was approximately 97,000 t annually in river basins and sea outlets. Applying an average cost of DAP phosphate (the common application of phosphate to soils) of EUR 1000 per tonne, it is estimated that the cost of phosphate loss in agricultural soils due to erosion costs the EU-27+UK between EUR 1.12-4.3 billion annually (accounting for the total phosphate content of 1 tonne of DAP phosphate-approximately 20%).
Another study by Steinhoff-Knopp et al. (2021)[387] estimated the impacts of soil erosion from water in Northern Germany. Using *monitored* soil loss rates (i.e. scenario 1) similar to that of Borrelli et al., between 0.0065- 0.0147 t km^2/yr across three sites, the study found that the potential supply of ecosystem services (including crop provision, water filtration, water flow regulation and fresh water provision) were impacted minorly. However, when applying *potential* soil loss rates (i.e. scenario 2) between 0.112- 0.2199 t km^2/year, significant decreases in potential supply of the aforementioned ecosystem services within the next 50 year period, particularly for crop provision. The study concluded that sustainable soil management practices to minimise erosion rates are important in order to preserve soil ecosystem services, yet context-specific soil composition and loss rates need to be considered in order to make conclusive correlations between soil erosion and ecosystem service relationships. As such, estimating EU-wide soil ecosystem service loss due to erosion is not possible within this study.

In relation to policy and legislation impacts on the soil erosion rates, a key policy in relation to soil erosion in agricultural soils are the provisions within the CAP.[388]

[386] Panagos, P., Köningner, J., Ballabio, C., Liakos, L., Muntwyler, A., Borrelli, P., & Lugato, E. (2022). Improving the phosphorus budget of European agricultural soils. Science of the Total Environment, 853, 158706.
[387] Steinhoff-Knopp et al., (2021) The impact of soil erosion on soil-related ecosystem services: development and testing a scenario-based assessment approach.
[388] Borrelli, P. and Panagos, P., An indicator to reflect the mitigating effect of Common Agricultural Policy on soil erosion, LAND USE POLICY, ISSN 0264-8377 (online), 92, 2020, p. 104467, JRC117064.

Consistent application of GAECs (i.e. cover crops, mulching, minimum tillage requirements) were demonstrated in the SOILCARE project to have a significant effect on reducing soil erosion (up to 90% reduction). However, this is an example analysis showing the potential role of policy, but cannot be assumed to be a projected achievement as it does not build on continuation of earlier trends. The analysis of GAEC 5 (tillage management for minimising risk of erosion) projects that due to the low requirements and exemptions available for MSs,[389] means that the trends presented in the figure above will not be impacted.

6.3 Evolution of the main problem: Land occupation and soil sealing

The Roadmap for a Resource Efficient Europe and the 7th Environmental Action Plan set a target of zero net land take by 2050, yet no action was mandated to MS, with efforts remaining voluntary. France is an example of MS which adopted a Zero net land take objective by 2050 as part of its Climate Law, as well as the objective of reducing by half the rate of land take in the next 10 years.[390] Similarly, Flanders has adopted a No Net Land Take objective for 2040[391] and Germany a target of reduction to maximum 30 hectares of soil sealing per day by 2030 and of net zero sealing by 2050.[392] However, such policies are not expected to be set by a large number of MS as they are not mandated by the EU. No corrections were therefore made in the baseline scenario in changes of the impacts on land take on the extent of the ecosystems, whereby the downward trends of land take can be expected to continue in the medium-long term. The implementation of the EU Soil Strategy and the land take hierarchy is expected to further contribute to this trend, yet the projected impacts are unknown as this will be dependent on MS action and ambition.

Regarding soil sealing, in the absence of legislation it is projected that the current annual average absolute rate of soil sealing in the EU-27 (332 km^2) will continue. Alternatively, a projection is made whereby this rate decreases by 20 km^2 per 5 years, to align with past trends reported in EEA 2019.[393] These two estimates are highlighted in Figure 6 below. The gradual decreased rate reaches 78,606 km^2 in 2050, whereas a continued average soil sealing rate reaches 81,546 km^2 by 2050.

A recent study[394] estimated that, in the EU-27+UK, the increase of sealed surface between 2012 and 2018 (approx. 1467 km^2) created an estimated carbon sequestration potential loss of approximately 4.2 million tons. Assuming that the loss of carbon sequestration potential per km^2 remains constant in the future, carbon sequestration potential loss could reach approximately 224.3 million tonnes between 2010-2050 under the gradual assumption, and 232.7 million tonnes under the continued soil sealing rate during the same time span. The same study estimated the loss of potential water storage in the same region due to soil sealing at 670 million m^3 in 2012-2018. Again assuming that the rate of water storage loss per km^2 of sealed surface remains constant in the

[389] EEB and Birdlife (2022) Soil and carbon farming in the new CAP: alarming lack of action and ambition. Available at: https://eeb.org/wp-content/uploads/2022/06/Briefing-Soil-Health-No-Branding-V2.pdf
[390] https://www.ecologie.gouv.fr/artificialisation-des-sols
[391] OECD Environmental Performance Reviews: Belgium 2021 https://www.oecd-ilibrary.org/sites/099a197b-en/index.html?itemId=/content/component/099a197b-en
[392] https://www.bundesregierung.de/resource/blob/998006/1873516/3d3b15cd92d0261e7a0bcdc8f43b7839/2021-03-10-dns-2021-finale-langfassung-nicht-barrierefrei-data.pdf#page=270
[393] EEA (2019) Imperviousness in Europe. Available at: https://www.eea.europa.eu/data-and-maps/dashboards/imperviousness-in-europe. Data here estimates that soil sealing rates slowed between 2006-2015 gradually.
[394] Tóth (2022) Impact of Soil Sealing on Soil Carbon Sequestration, Water Storage Potentials and Biomass Productivity in Functional Urban Areas of the European Union and the United Kingdom.

future, the loss of potential water storage could reach 35,779 million m^3 between 2010-2050 under the gradual assumption, and 37,117 million m^3 under the continued soil sealing rate. Such a loss of water retention capacity would increase the risk and severity of flooding. The study by Stürck et al. (2015),[395] also found that demand for flood regulating services are rapidly increasing throughout the EU (and demand is projected to continue to rise, largely due to growth of urban areas within flood-prone zones), whilst the supply of flood regulating services are projected to remain stable- ultimately leading to a deficit of flood regulating services in the coming years (the study projected this up to 2040).

The rate of land take in cropland has decreased significantly between 2000-2006 and 2012-2018. Considering this decreasing trend coupled with the results of a study which showed that the loss of potential agricultural production following soil sealing in 19 EU countries amounted to only -0.81% of potential agricultural production between 1990-2006,[396,397] impacts of land take on food production are not expected to be significant up to 2030 and 2050. However, there may be localised impacts, depending on the specific characteristics of the areas where land take occurs. For instance, one statistical study undertaken in the Parisian metropolitan area found that agricultural potential – amongst other ecosystem services – appear to be affected by soil sealing.

The same study also found that global climate regulation and urban heat island mitigation appear to be affected by soil sealing, whereas the relationship with other ecosystem services (e.g., groundwater recharge, flood regulation, the capacity of phosphorus retention and natural heritage) was more moderate, as also influenced by other factors and become noticeable in other locations.[398]

With regards to impacts on habitats and biodiversity, despite the commitment laid out in the Biodiversity Strategy to 2030 to enlarge the EU network of protected area[399] and the target for various ecosystems set in the proposal for a Nature Restoration Law,[400] it is estimated that continued land take trends will continue to incur significant detrimental impacts to biodiversity in the foreseeable future. The Nature Restoration Law also specifically mentions soil sealing in the case of urban green space, with the target of no net loss of green urban space by 2030, and an increase in the total area covered by green urban space by 2040 and 2050.

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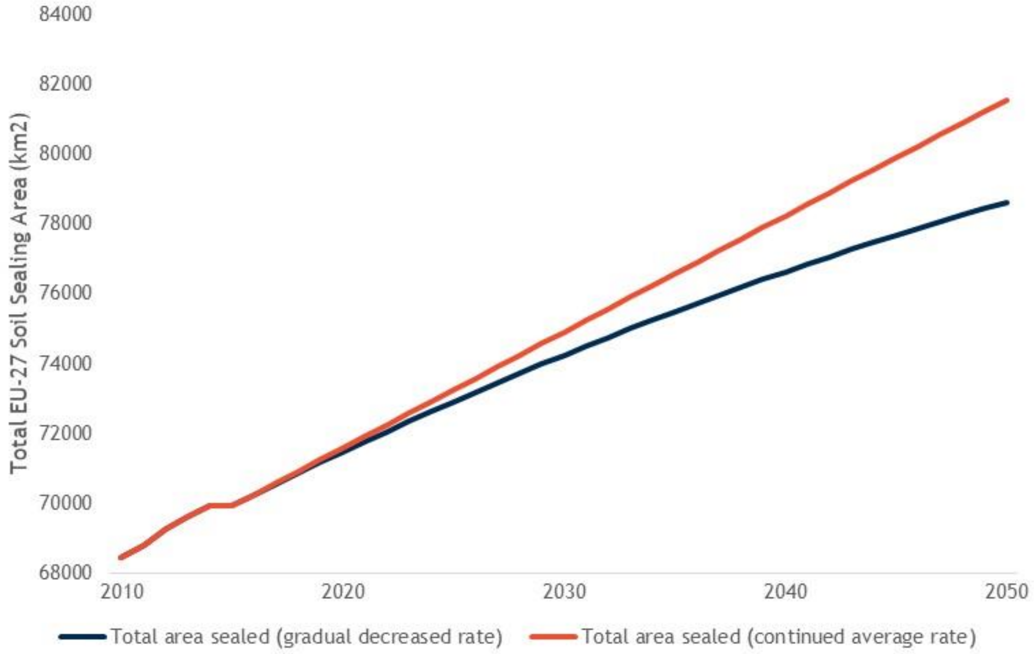
[395] Stürck et al., (2015). Spatio-temporal dynamics of regulating ecosystem services in Europe – The role of past and future land use change.
[396] Gardi et al., (2015) Land take and food security: assessment of land take on the agricultural production in Europe.
[397] Milder (2022) Environmental degradation: impacts on agricultural production.
[398] Tardieu et al., (2021) Are soil sealing indicators sufficient to guide urban planning? Insights from an ecosystem services assessment in the Paris metropolitan area.
[399] European Commission (2022) Biodiversity Strategy to 2030.
[400] European Commission (2022) Nature Restoration Law.

Figure 6-2: Projected total soil area sealed in the EU-27 to 2050

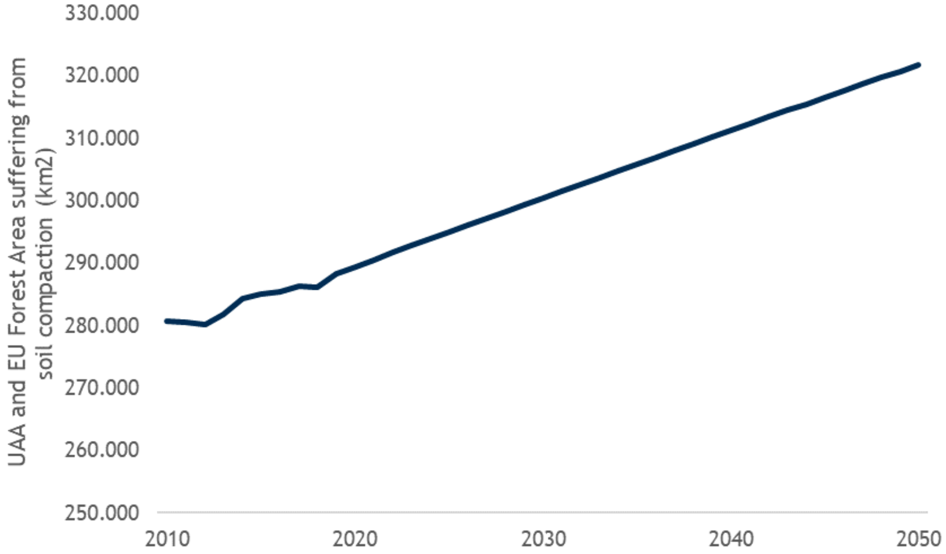


6.4 Evolution of the main problem: Compaction

The weight of agricultural machinery has steadily increased in the last 60 years in the EU,[401] and it is assumed that this trend will continue in the medium-long term, due to the projected continued intensification of agriculture. Furthermore, the climate change impacts on hydrological regimes are expected to exacerbate soil compaction issues in MSs particularly in Northern Europe due to the projected increase in winter precipitation- thus lowering soil ability to withstand mechanical stress.[402] As such, it is assumed that soil compaction will continue to impact EU agricultural soils, at an increasing rate.[403] No literature is available which outlines the potential rate of increase of agricultural soil compaction, therefore it is assumed that compaction rates will reach 26% in 2030, and 28% in 2050 (which is still below the estimated rate of 32% soils which are deemed highly susceptible by compaction.[404] Applying this to the projected UAA to 2050[405] is shown below, which is then added to the estimated compaction of forest soils (4.4% of the estimated total forest area growth expected).

[401] Keller et al., (2019) Historical increase in agricultural machinery weights enhanced soil stress levels and adversely affected soil functioning
[402] Stolte et al., (2016) Soil threats in Europe.
Available at: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/doc_pub/EUR27607.pdf
[403] EEA (2019) The European environment — state and outlook 2020
[404] JRC (2012) The State of Soil in Europe.
[405] Projected trends of utilised arable land are taken from EC (2021), EU agricultural outlook for markets, income and environment, 2021-2031 - which expects the EU-27 area to fall to 1,605,000km^2 by 2030. Applying the trends of utilised arable land between 2020-2030 were then project to 2050 (i.e. reaching a UAA of 1,551,128km^2 by 2050).

Figure 6-3: Projected area (km^2) of EU-27 Utilised Agricultural Area and forest area undergoing soil compaction



In relation to the impacts of compaction upon soil ecosystem services, subsoil (which contains more than 50% of global terrestrial carbon) microbial biomass carbon, soil porosity (key indicator for forest productivity- as this demonstrates the ability of air, water and dissolved organic matter delivery to soils), biodiversity of fauna and (indirectly) mycorrhizal fungi (due to decreased air supply from compaction- which can consequently impact nutrient uptake by tree roots) are significantly negatively impacted. Ultimately, the negative impacts of soil compaction upon these services can be detrimental to overall forest productivity.[406] Studies have shown that soil compaction can cause direct economic damage to timber products (through damaging tree roots- decreasing timber prices by 20%), yet impacts at the EU-scale cannot be estimated as this is largely dependent on the forest type.[407] Furthermore, compaction can lead to reductions in crop yield between 2.5-15%,[408] yet the precise correlation between increased compaction rates and relative crop yield reduction is not known, meaning no projections can be made.

As with the aforementioned baseline projections, the impacts of the CAP instruments which have the potential to positively impact soil compaction are currently not known presently,[409] nor can the impacts of the future revised CAP be projected. Positive impacts of the Nitrates Directive through grazer stocking density control can be expected to be continued- which ultimately do not impact the baseline projections outlined above.

6.5 Evolution of the main problem: Diffuse contamination

Estimating current soil contamination is highly challenging, given the lack of systematic monitoring, the plethora of pollutants known (over 700), variance between localised sites, and contrasting evaluation metrics deployed by MSs.[410] As highlighted in section

[406] Nazari et al., (2021). Impacts of logging-associated compaction on forest soils: A Meta-Analysis.
[407] ibid
[408] EEA (2019) The European environment — state and outlook 2020
[409] Alliance Environnement et al., (2020) Evaluation support study on the impact of the CAP on sustainable management of the soil. Available at: https://www.ecologic.eu/sites/default/files/publication/2022/3591-Evaluation-Support-Study-on-The-Impact-of-The-CAP-on-Sustainable-Management-of-The-Soil-web.pdf
[410] Maes et al (2020) Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment

the number of sites identified as being contaminated in the EU contested, and the area this impacts is unknown. For diffuse pollutants, studies have highlighted the challenge in assessing the area impacted in soils. Furthermore, there is an absence of projected data on pesticide contamination, POP, microplastics, veterinary products, pharmaceuticals, personal care products, and other emerging pollutants.[411] Despite these challenges, Panagos et al., (2013) [412] estimated that the costs for the management of contaminated sites is estimated at EUR 12.88[413] per capita in the EU from a sample of 11 countries who provided data on the budgets they allocated to such sites. If this is considered representative and upscaled to the EU-27, then it can be estimated that approximately EUR 5.7billion annually.[414]

According to one study, global mercury content in soils is expected to decrease due to specific control technologies and legal binding regulations, such as the Mercury Regulation.[415] In the EU, despite the use (manufacturing and processing) of mercury continuing to decline, predominant sources of contamination occur from outside the EU (up to 50% of anthropogenic mercury deposited in the EU is from air emissions outside the EU) and are not projected to decline in the near future.[416] Similarly, emissions of mercury in EU waters have remained relatively stable since 2010,[417] with sectors such as dentistry and chemical industries continuing to be the most significant contributing emitters.[418] As such, it is projected that mercury levels in EU soils remain stable up to 2030 and 2050. The predominant exposure pathway to humans is through the ingestion of predatory fish, whereas other pathways such as absorption through inhaled air and point-source pollution (through, for example, mercury mines) are limited in their impacts on human populations.[419] More detailed analyses, including on projections for soil contamination from other heavy metals, are lacking. The projections for copper concentrations are rather positive as the recent limitations imposed by EU regulation EU 2018/1981 (28 kg of copper per ha in 7 years) will have a positive effect in reducing fungicides treatment. However, the impact of EU target to increase organic farming at 25% has to be investigated in relation to copper application.

Regarding nitrogen, surplus projections (the difference between nitrogen inputs and outputs - not, indicating the actual excess of nutrients that enters soils/waters, but only the pressure from agricultural production) indicate similar trends to the baseline reference year, increasing slightly (approximately 1kg/ha/yr increase, EU average).[420] This projected increase is likely to impact disproportionately areas with intensive livestock production, such as the Benelux countries, Lombardy (Italy), followed by Brittany (France) and Catalonia (Spain). Phosphorus is projected to undergo similar minor increases in surplus to 2030.[421] No projections to 2050 are available, therefore it is assumed that 2030 trends continue to 2050. Ultimately, these projections indicate that the

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[411] Maes et al (2020) Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment
[412] Panagos et al (2013) Contaminated Sites in Europe: Review of the Current Situation Based on Data Collected through a European Network
[413] Adapted from original value in paper (€10.7 per capita) to account for inflation
[414] Assuming current EU-27 population of 446,559,279 – as per EUROSTAT (2022) Population on 1 January. Available at: https://ec.europa.eu/eurostat/web/population-demography/demography-population-stock-balance/database
[415] Krabbenhoft and Sunderland (2013) Global change and mercury.
[416] EEA (2018) Mercury in Europe's environment A priority for European and global action
[417] OECD (n.d.) Global Inventory of Pollutant Releases. Available at: https://www.oecd.org/env/ehs/pollutant-release-transfer-register/
[418] EEA (2018) Mercury in Europe's environment A priority for European and global action
[419] EEA (2018) Mercury in Europe's environment A priority for European and global action
[420] De Vries et al., (2022) Impacts of nutrients and heavy metals in European agriculture. Current and critical inputs in relation to air, soil and water quality, ETC-DI; EC (2021), EU agricultural outlook for markets, income and environment, 2021-2031.
[421] EC (2021), EU agricultural outlook for markets, income and environment, 2021-2031.

thresholds for N deposition will continue to be exceeded in the future, causing continued negative impacts on soil health.

Given the lack of comprehensive data on pesticide application, and the absence of data on pesticide sales for numerous MSs, it is not possible to project future pesticide usage in the EU. However, given the persistent presence of pesticide residues and its metabolites in soils, detrimental impacts to soil health can be expected to 2050. The same conclusions apply to POPs more broadly speaking.

As aforementioned, micro- and nano-plastic pollution in soils depends on contamination from abrasion, application of manure and sludge on agricultural soils, and waste disposal, for which data on current contamination and – by extension – on future trends is lacking. However, expected future trends on plastic consumption can give an estimation are available. Demand for plastic is not expected to reduce dramatically in Europe. One study estimated that demand for plastic in the fields of packaging, household goods, construction, and automotive would grow by 30% between 2020 and 2050, reaching 48Mt by then.[422] Another study based on modelling showed that even under a reduced plastic use and improved waste management scenario, plastic waste production will not drastically be reduced.[423] This means that without further action to address plastic contamination in soils,[424] the rate of plastic accumulation in soils is not expected to significantly decrease.

Such trends could have implications for environmental and human health in the future. In 2019, a SAPEA evidence review report on the topic estimated that although microplastic pollution does not constitute yet a widespread health risk, a continued business-as-usual scenario could lead to widespread risk within a century (i.e., beyond the baseline limit set at year 2050), and that evidence provides grounds for genuine concern and for precaution to be exercised.[425] Potential effects on agricultural yields have not yet been quantified in existing literature.

For veterinary products, the decreasing trend in sales is expected to continue in the future due to the evolution of the EU regulatory framework on veterinary medicinal use in the EU (notably via Regulation on Veterinary Medicinal Products (Regulation 2019/6) and the Regulation on Medicated Feed (Regulation 2019/4)).[426] Conversely, the consumption of medicines by humans is expected to sightly increase in Europe, at least in the shorter-term, with a growth in spending of $51 billion through 2026 being foreseen, with a focus on generics and biosimilars.[427]

Further control of the emission of pollutants under the Industrial Emissions Directive may lead to reduced (surface) water and soil pollution in the future, yet it is unclear to what extent this will have an impact.[428]

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[422] https://plasticseurope.org/wp-content/uploads/2022/04/SYSTEMIQ-ReShapingPlastics-April2022.pdf
[423] https://www.nature.com/articles/s41599-018-0212-7#Sec7
[424] For instance, one study on the release of microplastics into soils from waste-water treatment plants notes that there remains inadequate solutions for the explicit release and control of MP pollution into the environment from WwTPs, both due to the management practices of this pollutant at the plants and the absence of EU legislation.
[425] https://sapea.info/topic/microplastics/
[426] PAN Germany (2021) Veterinary Medicine in European Food Production. Available at: https://noharm-europe.org/sites/default/files/documents-files/7022/2022-02-03_Veterinary-medicine-in-European-food-production_EN.pdf
[427]https://www.iqvia.com/-/media/iqvia/pdfs/institute-reports/the-global-use-of-medicines-2022/global-use-of-medicines-2022-outlook-to-2026-12-21-forweb.pdf?_=1656501812146
[428] EEA (2019) The European environment — state and outlook 2020

6.6 Evolution of the main problem: Loss of Soil Organic Carbon (SOC)

Changes in the forthcoming new CAP (2023-27) may impact SOC, yet previous evaluations have found little evidence of the promotion of practices which may enhance SOC (such as crop residues/compost application and measures for soil erosion). [429] Currently, it is difficult to predict how measures in the new 2023-2027 CAP period will impact SOC. GAEC 2, through protecting carbon rich soils, could potentially lead to positive impacts on SOC. However, this GAEC does not require MSs to halt and reverse degradation, and MSs can request delays in establishing standards until 2025 (14 MSs have requested to do so). As such, minimal impacts from the CAP on SOC in agricultural soils are expected, and the current degradation rate of SOC of 0.07% (5.7Mt of C per annum) per annum, equivalent to EUR 425-850 million per annum.[430]

Other policy developments may also impact SOC moving forward- particularly the shift towards a bio-based economy (2018 EU Bioeconomy Strategy) It could be reasonable to expect increased pressure on agricultural land and forest through an increased demand for agricultural and forestry products. In turn, this could directly impact the use of residues which have both been linked to increased losses of SOC. Furthermore, the Sustainable Carbon Farming Cycles Policy, and subsequent regulatory framework for an EU certification of carbon removals, are projected to enhance the scale of natural carbon sinks throughout the EU (the target is to contribute 42 Megatons of CO2 equivalent storage per year to Europe's natural sinks by 2030), yet the impacts of this on restoring healthy soils are unclear.

In relation to climate change, the impact on SOC varies across ecosystems and soil types leading to uncertainties projections.[431,432]Organic soils are also predicted to be highly vulnerable to warming meaning that SOC mineralisation and GHG emissions from peatlands are likely to increase with climate change.[433] Climate change is also projected to impact SOC through increased floods and landslides- which in turn will lead to increased soil erosion and loss of SOC. Current rates of SOC loss due to erosion are calculated at 1.8-2.2 million t/yr in the EU-27+UK (equivalent to an estimated cost of EUR 130-325 million per year from carbon loss).[434]

Regarding organic soils, no further loss in Habitats Directive Annex I peatlands or marshlands are expected,[435] yet the estimated 45 000 – 55 000 km^2 of drained organic soils will continue to lose carbon unless rewetted. New CAP measures (GAEC 2 on the protection of carbon-rich soils) could prevent further SOC loss, yet no specific requirements beyond what is currently in place are expected. Ultimately, it is projected that no significant changes to current trends are expected in mineral soil SOC to 2030 and 2050, organic soils in degraded/drained areas will continue to lose carbon to 2030 and 2050. No quantified estimates of projections could be located in literature.

[429] Alliance Environnement et al., (2019) Evaluation of the impact of the CAP on habitats, landscapes, biodiversity
[430] Using a market price of carbon between €20-40 per tonne. Taken from De Rosa et al (2022)- under production.
[431] Lugato et al., (2021). Different climate sensitivity of particulate and mineral-associated soil organic matter
[432] Yigini and Panagos (2016) Assessment of soil organic carbon stocks under future climate and land cover changes in Europe
[433] Hopple et al (2020) Massive peatland carbon banks vulnerable to rising temperatures
[434] Using a market price of carbon between €20-40 per tonne. From, Lugato et al., (2018) Soil erosion is unlikely to drive a future carbon sink in Europe.
[435] Trinomics et al., (forthcoming) IA study on EU Biodiversity Strategy to 2030

The relationship between SOC and ecosystem services, particular the provision of crops and water retention capacity, is complex. Panagea et al.,[436] found that the correlation between the water retention property of soils and organic carbon content were negligible, whilst Vonk et al. (2020)[437] found that SOC impacts on crop yields varied between the type of crops grown and the climate and soil types they were grown in. As such, no projections can be estimated with confidence.

6.7 Evolution of Sub-Problem A: Information, data and management gaps for soils

The current scientific gaps in the definition of soil health descriptors and of thresholds on these descriptors to consider a soil as 'healthy' are the purpose of intensive collaborative work, specifically in the EJP Soil.[438]

It can be anticipated that these converging efforts will be carried on, leading to a form of harmonisation in the scientific community of the most meaningful descriptors, likely before 2030.

The soil data aggregation work performed since 2006 by the common repository of ESDAC[439] is likely to continue and improve.

In the absence of EU legislation on the harmonisation of data collection, sampling and interpretation, the datasets being collected at Member State level and aggregated by ESDAC are likely to remain heterogeneous, even if some comparability between measurement results is obtained via empirical transfer functions.
Indeed, the monitoring of soil implies soil sampling and analysis, which need public resources, scarce in several Member States. In addition, the Member States that have set up their national soil monitoring system, sometimes for decades, are willing to maintain the continuity of their datasets, so as to be able to assess the evolution of soils over the long term. Their appetite for a more harmonised approach at EU level, in the absence of an EU legal requirement, is likely to remain low.

Similarly, the setting of thresholds has implications on the surface of land deemed 'unhealthy' and hence (at least politically, if not legally) deserving some corrective action, which tends to be profitable in the long term, but not in the short term, and hence face political resistance.

Similarly, the progress on the collection of data regarding the contamination status of soils has been extremely slow over the last decade, with only 11 EEA Member States among 33 having set up a comprehensive registry of contaminated sites in 2016, despite legislation at national level having started in pioneering countries already in the 1980s. It is thus likely that such differences in the availability and quality of data regarding contaminated sites, specifically regarding the nature of (1) the potentially contaminating

[436] Panagea et al., (2021) Soil Water Retention as Affected by Management Induced Changes of Soil Organic Carbon: Analysis of Long-Term Experiments in Europe
[437] Vonk et al., (2020) European survey shows poor association between soil organic matter and crop yields
[438] https://ejpsoil.eu/about-ejp-soil
[439] Panagos, P., Van Liedekerke, M., Borrelli, P., Köninger, J., Ballabio, C., Orgiazzi, A., Lugato, E., Liakos, L., Hervas, J., Jones, A., & Montanarella, L. (2022). European Soil Data Centre 2.0: Soil data and knowledge in support of the EU policies. European Journal of Soil Science, 73(6), e13315. https://doi.org/10.1111/ejss.13315

activities eliciting a deeper investigation and (2) of the contaminants being searched for on the sites identified as potentially contaminated.

6.8 Evolution of Sub-Problem B: Transition to sustainable soil management and restoration is needed but not happening e.g. for the unsolved legacy of contaminated sites

The main barriers to the adoption of more sustainable soil management practices, despite their long-term advantages, have been identified to relate to:

- the perceived risk of irregular or lower yields and quality of the crops, in a context where the farmers' customers (retailers and agro-food industry) demand constant and predictable quantities and quality;
- the lack of technical knowledge on these practices and of appropriate skills transmission advisers.[440]

The requirement for constant and predictable quantities and quality of food products is a structural feature of the current agro-food value chain, which developed over the decades since the Second World War. In the absence of explicit EU policy, this requirement is unlikely to evolve spontaneously towards a setting more friendly to sustainable soil management practices in the coming decades.

The pace at which contaminated sites are remediated is slow and very uneven among EU Member States, with rates varying between 20 sites/year, up to 3000 sites/year and a total number of sites under remediation in a given year stagnating, with figures as follows: 6269 (2005), 12,073 (2011) and 10,539 (2016), to be compared to the 166,000 sites expected in 2016 to be in need for risk reduction measures or remediation.

Assuming a median remediation rate per country of 129 sites/year (2016), it would take 47 years to remediate all expected contaminated sites (it would take 10 years if the statistical average of 614 sites/year/country would be used for this projection, i.e. if the remediation capacities of Member States were pooled into a common resource – an unlikely hypothesis).[441]

[440] Buckwell, A., Nadeu, E., Williams, A. 2022. Sustainable Agricultural Soil Management: What's stopping it? How can it be enabled? RISE Foundation, Brussels. https://risefoundation.eu/wp-content/uploads/2022_SOIL_RISE_Foundation.pdf
[441] EEA (December 2022) Progress in the management of contaminated sites in Europe https://www.eea.europa.eu/ims/progress-in-the-management-of

ANNEX 9: IMPACTS OF THE OPTIONS (ASSESSMENT SHEETS)

1 APPROACH TO THE ANALYSIS

1.1 Overview and impact screening

As seen in the proposed Intervention Logic, the Soil Health Law is intended to be made of a set of 'building blocks', aimed at addressing the Sub-problems identified. The 5 'building blocks' being considered are listed below:

- Soil Health and Soil Districts (SHSD);
- Monitoring (MON);
- Sustainable Soil Management (SSM);
- Definition and identification of contaminated sites (DEF);
- Restoration of soils to healthy status (REST) / Remediation of contaminated sites (REM).

These 'building blocks' are complemented by 4 additional sets of measures, named 'add-ons', which are studied separately hereafter for the sake of analytical clarity:

- Land take (LATA);
- Soil Health certification (CERT);
- Soil passport (PASS);
- Nutrients targets (NUT).

A range of options have been defined against each building block which will come together to form the Soil Health Law. Each of the options will have a number of associated impacts, with the exact impacts, their size and significance depending on the individual option. To assess the impacts, the study has followed a methodology designed to meet the requirements of the Better Regulation Guidelines[442] and to provide the European Commission with timely evidence collection, stakeholder engagement and analysis of information gathered.

Based on the Better Regulation Guidelines, interventions should be compared against the baseline on the basis of how they address the objectives, considering their effectiveness, efficiency and coherence. All options were screened for their likely key impacts against the long-list of potential impacts as defined in Tool #18. An initial assessment of the expected absolute and relative magnitude of these impacts and their likelihood was carried out to produce a general shortlist of impact types, prioritised on the basis of their likely significance, that were carried forward for more detailed assessment. This shortlist was used as a general guide for the assessment of all options - not all impacts were rigidly assessed for all options as in some cases, the impacts were subsequently considered insignificant for specific options. In the assessment, greater attention was paid to those options identified as 'high priority' and greater effort made to quantify these effects, in contrast to those defined as 'low priority' which were assessed qualitatively. The result of this screening of impacts was that 35 economic, environmental, and social impact categories were generally selected for further consideration and assessment as part of this study of which 11 were identified as 'high priority'. The impact screening alongside a brief description of the specific impacts and proxy indicators considered in

[442] https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en

this assessment of options for Soil Health Law are also provided for clarity in the table in section 8.

1.2 Assessment of impacts

1.2.1 Quantitative and qualitative assessment

Across each of these specific indicators, available evidence on the effectiveness, efficiency and coherence of the options was collated, assessed in comparison to the baseline. Where possible the study has sought to quantitatively assess the impacts, but this has not been possible in all cases. Where quantification was not possible, impacts were assessed in a qualitative way, clearly indicating the type of most important impacts and their likely magnitude. The subsequent sections of this annex assess the impacts of each option under each building block separately.

1.2.2 Economic impacts associated with SSM and remediation measures

One area of focus for the quantification of impacts was the economic costs and benefits associated with implementing both sustainable soil management (SSM) practices and remediation of contaminated land (REM).

The analysis of ***SSM practices*** supports the assessment of the 'adjustment costs' and the linked 'conduct of business' impacts associated with the SSM and Restoration (REST) building blocks – further details of this analysis are set out in section 7. The analysis does not cover administrative burden which is assessed separately (see next section). This analysis is subsequently drawn on in the combined assessment of impacts in each Assessment Sheet in the subsequent sections in this report below.

A wide range of SSM practices exist that have varying applicability across different climates, soil types and land-uses. Furthermore, the type of environmental benefits delivered and soil threat targeted differ by practice, and importantly the costs and benefits of each practice can vary widely depending on the location, means and extent of implementation. For this impact assessment study, given limitations in the underlying evidence base, a sample of SSM practices have been selected for quantitative analysis to illustrate the potential costs and economic benefits associated with such measures. Measures were selected that were deemed more universally applicable, and likely to deliver significant economic benefits. These were also selected to ensure a broad coverage of soil threats.
For each SSM practice, publicly available existing literature and data have been used to build a bottom-up quantification of economic costs and the benefits, scaled up to the EU level. As noted, there are many environmental and social benefits associated with undertaking SSM practices, however, this work focuses purely on the economic costs and benefits e.g., impacts on yields or impacts on fertiliser use.

This analysis sought to illustrate the order of magnitude of effects that could be expected if the selected SSM practices were implemented. In practice, the true impacts of the SHL package will depend on the exact practices, location and extent of their implementation.

1.2.3 Standard Cost Modelling

In light of the EC's "one-in-one-out" agenda, a second area of focus for quantification was the administrative burdens associated with the options. A bottom-up cost modelling approach was employed to estimate the additional administrative burden on businesses, citizens and public authorities that would result from the adoption of the options, inspired by the Standard Cost Modelling approach outlined in Tool #58 of the Better Regulation Toolbox. Here three general steps were taken:

1. **Preparatory analysis**. First, this included the qualitative identification of the scope and type of potential administrative impacts of the options on businesses, citizens and public authorities. This was followed by the identification of evidence needs, e.g., baseline administrative requirements and additional inputs required, their intensity and frequency over a period (e.g. 20 years) and unit costs. Finally, sources were identified and desk research and a rapid evidence review were carried out, building on the consultation activities, and other key sources of evidence.
2. **Data capture and standardisation**. The data available was collated for all the parameters identified in step 1, generally structured and saved within an Excel workbook.
3. **Calculation**. A specific baseline for each option was quantified in line with the baseline established, and the potential additional administrative burden generated by the options were calculated employing the bottom-up cost modelling approach.

Furthermore, annual averages or annualised figures were calculated and presented for comparison. A 3% real discount rate was employed as outlined in the EC's Administrative Burden Calculator. These assessments were quality assured by experts and validated, and uncertainties and sensitivities considered.

1.2.4 Subsidiarity

Several options have been identified under each of the five core building blocks and four add-ons. Across the core five building blocks, the key difference between the options is subsidiarity: generally Member States are given greater flexibility to define components of the options under Options 2 across the building blocks, with maximum harmonisation under Options 4 where a greater level of definition is achieved centrally by the EU (with Option 3 representing a mid-way point between the two). In light of this, a key consideration in comparing between the options therefore is the potential impact that different levels of subsidiarity could have on implementation in practice. This is a key area of uncertainty in the analysis (as noted in the limitations section below). Therefore, to help inform consideration around the options, it was considered pertinent to consider the experience observed in other areas of EU legislation with similarities and parallels to soil health. A review of experience under the Water Framework Directives and Ambient Air Quality Directives, and a reflection on the level of subsidiarity under these Directives and the bearing that has had on outcomes, is presented in the information box below.

Information Box - Subsidiarity in environmental legislation on water and air – Lessons learnt from the cases of the Water Framework Directive and the Ambient Air Quality Directive

In considering the issue of subsidiarity in relation to soil, there are important lessons that can be learned in relation to the approaches employed at the EU level to address water and air quality. This box summarises the approaches employed, the benefits derived and the problems encountered in relation to the level of subsidiarity addressed in each instrument.

Addressing water quality in the EU – The Water Framework Directive (WFD)[443]
European water legislation began in 1975 with the setting of standards for European rivers and lakes used for drinking water abstraction and bathing water. In 1980, binding quality targets were set for drinking water, and legislation was subsequently introduced on the quality of fish waters, shellfish waters and groundwater. At that time, the main emission control instrument applied to water-related directives was the Dangerous Substances Directive.

In 2000, EU water policy underwent a consolidation process, which led to the adoption of the **Water Framework Directive** WFD. Its aim was to promote a more holistic approach to water policy, streamlining existing freshwater legislation and adopting a river basin management approach. The WFD included a provision under which the Directive would be complemented to further refine the assessment of water status. The Environmental Quality Standards Directive (EQSD) and Groundwater Directive (GWD) were subsequently adopted in 2008 and 2006 respectively. The WFD is the most comprehensive and overarching instrument of EU water policy. It applies to fresh, coastal and transitional waters and ensures an integrated approach to water management respecting the integrity of whole ecosystems. It provides direction for and coherent links with several other EU Directives relevant to water. The environmental objectives of the WFD are to:
- prevent deterioration of the status of water bodies; and
- protect, enhance and restore all water bodies, aiming to achieve good ecological status or good ecological potential and good chemical status for surface waters, as well as good quantitative and good chemical status for groundwater by 2015 (as laid down in its Article 4(1)).

Preventing further deterioration is thus key in the path towards achieving good status.
The 2008 **Environmental Quality Standards Directive (EQSD),** a 'daughter' of the WFD, established environmental quality standards (EQS), as required by WFD Article 16(8), for the 33 priority substances listed since 2001 in Annex X to the WFD, and for eight other pollutants already regulated at EU level. The EQS are the concentrations that should not be exceeded, either on an annual average basis (AA-EQS) or at any time point (Maximum Allowable Concentration EQS). These standards are used to determine the chemical status of surface water. Based on a scientific review of more than 2,000 substances, the EQSD was revised in 2013, and thereby also Annex X to the WFD. Twelve substances were added to the priority substances list, including additional industrial chemicals, biocides, and plant protection products. The WFD requires the Commission to submit proposals for controls to reduce emissions, discharges and losses of all priority substances and eight other pollutants and to cease or phase out emissions, discharges and losses of the subset of priority hazardous substances.

As required by WFD Article 17, the 2006 **Groundwater Directive** (GWD), another 'daughter' of the WFD, has as its main focus the prevention and control of groundwater pollution, with a view to ensuring the protection of drinking water sources and of

[443] Note that this material is based upon SWD (2019) 439 Fitness Check of the Water Framework Directive and the Floods Directive

dependent ecosystems. The GWD was introduced to clarify the criteria in the WFD for good chemical status of groundwater, a task too complex to finalise at the time the WFD was adopted.

One of the main challenges for water policy to be effective is that some of the pressures on water, and the measures required to mitigate them, are location-specific. At the same time, some pressures require a similar approach across Europe. Many water issues are also transboundary: all Member States except Malta and Cyprus share international river basins, meaning that changes in one Member State can have an impact on the hydrology or water quality in other Member States. This requires an integrated approach, both across administrative borders and across different policy areas.

In addressing the location-specific nature of pressures on water, the WFD introduced water governance based on river basins (i.e. natural boundaries) rather than on administrative or national borders. This is because river basins differ from each other both in their natural and socioeconomic conditions and because the status of water bodies downstream depends on appropriate measures being taken upstream, in line with the principle of subsidiarity. As a consequence, all Member States have adapted their administrative and governance systems: some Member States have established specific river basin district authorities, while several others have adapted existing water administrations to ensure better implementation.

Taking into account the principle of subsidiarity, the Directives responded to these challenges by introducing a flexible framework which promotes an integrated approach to deal with all different pressures on water across different policy areas. This leaves considerable discretion to the Member States to set location-specific objectives, methodologies and measures, while ensuring harmonisation and a level playing field.

One drawback of an approach based on subsidiarity is that for certain issues there are considerable variations in how Member States have implemented the Directives, where a more uniform approach may have been desirable. These variations may in some cases be due to local differences, but in many cases can only be explained by various other factors, such as political, resistance to change or lack of technical capacity.

One example of an issue where methodological harmonisation has been insufficient is the way in which hydromorphological quality elements are linked to biological quality elements, which varies between Member States. Likewise, the implementation of Article 4(7) of the WFD on how to deal with new physical modifications to water bodies differs considerably from one Member State to another. Similarly, the way in which Member States designate specific water bodies as heavily modified, and the way in which good ecological potential is defined in those water bodies, are also highly variable. Work on these aspects is ongoing, and the results were expected to contribute to a more harmonised approach in the third cycle of RBMPs that are currently being assessed.

Another example is the large variability in the river basin-specific pollutants that have been identified by the Member States. While it is expected that different pollutants are identified as posing risk in different RBDs, there is no clear justification for the standards used for the same pollutant to be very different for different RBDs.

It is apparent in the case of the WFD that in some cases the subsidiarity approach applied has led to varying levels of implementation across Member States.

Addressing air quality in the EU – the ambient air quality Directive[444]

Air quality has been understood as a key environmental challenge for several decades. EU level policy interventions started already in the 1980s and expanded in the late 1990s and 2000s. Most of the provisions found in the currently applicable versions of the AAQ Directives were originally established either via the Air Quality Framework Directive in 1996 or in one of the four Daughter Directives adopted between 1999 and 2004.Previous policy interventions already led to the establishment of most of the EU air quality standards applicable today as well as of a comprehensive monitoring network. By 2005, Member States were monitoring air quality at around 3 000 locations and routinely disseminated this information to the public and the Commission (albeit not using a system of electronic reporting based on a shared information system yet).

In 2005, the Thematic Strategy on Air Pollution presented a detailed assessment of the situation at the time as basis for a revision of EU Clean Air Policy. It concluded that “air pollution continues to diminish the health and quality of life of EU citizens as well as the natural environment. The magnitude of these effects is too large to ignore and doing nothing more beyond implementing existing legislation is not a sensible option.” As regards the AAQ Directives specifically, the Thematic Strategy included a legislative proposal to combine the Air Quality Framework Directive and first three Daughter Directives, while suggesting that the fourth Daughter Directive would be ‘merged later through a simplified “codification” process’. The resulting legislative changes resulted in two complementary ***EU Ambient Air Quality (AAQ) Directives*** (2008/50/EC and 2004/107/EC, as augmented by Commission Directive (EU) 2015/1480). These Directives set air quality standards not to be exceeded throughout the EU, and requirements to ensure that Member States adequately monitor and/or assess air quality in a harmonised and comparable manner. They are complemented by an Implementing Decision laying down the rules for reciprocal exchange of information and reporting on ambient air quality.

The EU Ambient Air Quality (AAQ) Directives are guided by the overarching need to reduce air pollution to levels which minimise harmful effects on human health, the environment as a whole and the economy, taking into account relevant guidelines i.a. by the World Health Organization. A basis for effective air pollution reduction is proper monitoring and assessment of air quality, whereas providing information to the public can support the minimisation of harmful health effects and help raise awareness.

First, the AAQ Directives set common methods and criteria to assess air quality in all Member States in a comparable and reliable manner: Member States must designate zones and agglomerations throughout their territory, classify them according to prescribed assessment thresholds, and provide air quality assessments underpinned by measurement, modelling and/or objective estimation, or a combination of these.

Second, the AAQ Directives define and establish objectives and standards for ambient air quality for 13 air pollutants to be attained by all Member States across their territories against timelines laid out in the Directives. These are: sulphur dioxide (SO2), nitrogen dioxide (NO2) and nitrogen oxides (NOx), particulate matter (PM10 and PM2.5), ozone

[444] Generally taken from “FITNESS CHECK of the Ambient Air Quality Directives Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air and Directive 2008/50/EC on ambient air quality and cleaner air for Europe” SWD (2019) 427 final

(O_3), benzene, lead, carbon monoxide, arsenic, cadmium, nickel, and benzo(a)pyrene.

Third, the Directives require Member States to monitor air quality in their territory. Member States need to report to the Commission as well as to the general public, the results of air quality assessment on an annual basis, 'up-to-date' air quality measurements, as well as information on the plans and programmes they establish. It is the responsibility of Member States to approve the measurement systems required and ensure the accuracy of measurements.

Fourth, where the established standards for ambient air quality are not met, the Directives require Member States to prepare and implement air quality plans and measures (for these pollutants exceeding the standards). These air quality plans need to identify the main emission sources responsible for pollution, detail the factors responsible for exceedances, and spell out abatement measures adopted to reduce pollution. Abatement measures can include, for example, measures to reduce emissions from stationary sources (such as industrial installations or power plants, as well as medium and small size combustion sources, including those using biomass) or from mobile sources and vehicle (including through retrofitting with emission control equipment), measures to limit transport emissions through traffic planning or encouraging shifts towards less polluting modes (including congestion pricing or low emission zones), promoting the use of low emission fuels, or using economic and fiscal instruments to discourage activities that generate high emissions.

Guided by the principle of subsidiarity, the AAQ Directives leave the choice of means to achieve their air quality standards to the Member States, but explicitly require that exceedance periods are kept as short as possible.

As part of the fitness check of the two air quality Directives it was pointed out that the system to measure air quality still has room for improvement but delivers data that is good enough to act upon; that enforcement is partially effective, also thanks to NGOs successfully taking legal action; that implementation respects the subsidiarity principle, but has suffered from a lack of political commitment and coordination between levels of government. In this respect the overall conclusion in 2019 was that they have been partially effective in improving air quality and achieving air quality standards. It also acknowledged that they have not been fully effective and not all their objectives have been met to date, and that the remaining gap to achieve agreed air quality standards was too wide in certain cases.

1.3 Key data sources

1.3.1 Literature review

The literature review formed a critical part of the data collection and was evidence base underpinned. The literature review included materials from a wide range of stakeholders, including industry, local and national governmental authorities, researchers, and non-governmental organisations (NGOs). Key data sources included existing policy reports from the European Commission and other public bodies (including existing evaluations, impact assessments, studies, audits, information on infringements, complaints, court rulings), academic papers, techno-scientific publications, databases, in particular data from EUROSTAT to support the quantitative assessment; and other grey literature, such as position papers, proceedings of conferences, symposia and meetings. The literature review started with the identification of ‘information and data’ needs for the overall project along with the identification of relevant data sources. The identified literature was subject to a preliminary screening that determined the availability and reliability of information. A final list of relevant references was then identified, allowing a critical assessment of the information gathered. The detailed review of the literature allowed the identification of potential gaps, contradictory statements, and additional questions that were then discussed during the consultation activities.

1.3.2 Consultation activities

This section provides an overview of the consultation activities undertaken. The consultations conducted sought to validate or refine any findings (from the above analytical steps) and to fill any identified information gaps. Four forms of consultations took place, as outlined in the following sections.

1.3.3 Call for evidence

The call for evidence took place between 15 February- 16 March 2022, receiving 189 responses. The majority of respondents were EU citizens (n=41, 22%), business associations (n=37, 20%) and non-governmental organisations (n=35, 19%). The majority of respondents supported/ strongly supported the Soil Health Law (n=149, 79%), despite a number of critiques and concerns

1.3.4 Online public consultation

An online public consultation was accessible between 1 August- 24 October 2022, receiving a total of 5,792 responses. The questionnaire consisted of: 1) a general section focused on views on soil health issues which did not require technical or expert knowledge of the Directives, and 2) a specialised section addressed to respondents with such knowledge. The questionnaire covered aspects related to, inter alia, the drivers of soil degradation, the current management of these drivers, and views on potential measures to address soil degradation. In addition to the questionnaire, respondents were given the opportunity to provide any further documentation (such as position papers, scientific literature, sector analysis reports). A total of 75 documents were received, and analysed as part of the impact assessment.

1.3.5 Targeted interviews and engagement

As part of the consultations, two interviews were organised with German (Federal Ministry for the Environment) and Austrian (Federal Ministry of Agriculture, Regions and Tourism) representatives- due to their respective pioneering soil legislations. These interviews focused on learning from experiences and filling gaps in knowledge on the costs and benefits related to health soil legislations, notably around the feasibility and means of implementation of the various options considered.

In addition to these interviews, a targeted questionnaire was disseminated to identified expert stakeholders between 14-28 November. The questionnaire sought to fill any information gaps throughout the impact assessment, with questions directed to stakeholders with relevant experience related to each of the thematic areas outlined in the sections below. A total of 18 responses were received.

1.3.6 Meeting of the soil expert group

A stakeholder meeting took place on 4 October 2022, consisting of members of the enlarged expert group on the implementation of EU Soil Strategy for 2030. The event was hybrid- with both in-person (n=56) and online participants (n=82) present. The meeting focussed on gathering stakeholder feedback on the potential options put forward in the Soil Health Law, with specific Q&A sessions for each of the thematic areas explored.

1.4 Limitations and summary assessment

1.4.1 Limitations of the analysis

The strength of an impact assessment is linked to the robustness of the evidence that has been gathered. Information on robustness of evidence and uncertainty and caveats around each analysis step are included throughout the assessment under each relevant section. In addition, the following key limitations are important to note:

- ***Some impact drivers will only be realised after adoption and upon implementation of the measures under the SHL package:*** In some cases, particular elements or detail of the options will not be realised until after adoption. This is particularly the case for Options 2 under the building blocks, where greater flexibility is left to Member States in implementation. Hence the details of the options which will be implemented in practice will not materialise until Member States have transposed the regulation and determined these elements at national level. For example, under the SSM building block, exactly what SSM practices will be mandated for landowners and harmful practices prohibited in each Member State will not be known until these are selected by the corresponding Competent Authority.

  To mitigate this limitation these uncertainties were acknowledged throughout the assessment where relevant; and gathered together evidence qualitatively and quantitatively to explore and illustrate the type and range of possible impacts, and their drivers (e.g. for SSM practices, the analysis draws on evidence in the underlying literature to show the impacts associated with a range of different SSM practices).

- ***Quantitative data around the impacts of SSM practices, restoration and remediation measures is limited and dispersed:*** In the literature, some evidence and data is available which can be used to quantify the impacts of the options. In particular, for example, there is good evidence of the benefits of SSM practices at farm level, and the JRC have produced a strong body of work around the costs of remediation measures. However, there are a number of limitations and gaps in the evidence base which have prevented a complete assessment of the overall costs and benefits of these options. In particular:
  - quantitative data is not available for all measures or practices;
  - where information is available, this is often spread across different sources drawing on different primary inputs, increasing the risk of a lack of consistency between sources;
  - the impacts of measures or practices will differ strongly by location based on specific parameters – information is often only available from 1 or 2 case

studies with specific contexts, and not often available at the scale of whole EU Member States;

- effects will also differ depending on other factors, such as the extent of implementation or the measures with which they are co-implemented – again evidence is only available for a limited set of implementation scenarios.

  Hence, there is no one model, set of models or set of evidence which could be used to produce a complete quantitative assessment of the costs and benefits of SSM practices, restoration and remediation measures which may be implemented under the options.

To mitigate this limitation, gathering of the data available was sought and illustrative estimates of the costs (and economic benefits) of deploying a sample of 5 widely accepted SSM practices EU-wide were produced. Many simplifying assumptions are made to develop these estimates and as such there will be a wide of uncertainty around the results produced, but it is intended that these provide an order-of-magnitude estimate of the potential costs associated with the options under the SSM and restoration building blocks.

- ***Quantitative data around the environmental impacts of SSM practices, restoration and remediation measures is severely limited:*** although there is good evidence and a strong consensus around the environmental benefits of such measures, quantitative data which can be used to provide a reliable estimate of the change in environmental benefits associated with implementing a given measure is severely limited for most practices. Where this evidence is available, it is only available for a handful of measures in specific circumstances, with uncertainty around its replicability across the EU.

  To mitigate this limitation the qualitative evidence available in the underlying literature was brought together to illustrate the type, nature, direction and potential significance of effects. Where this has also included a quantification or monetisation of effects, these are also presented and have been reviewed to check whether they could be updated. This can provide a useful baseline against which to compare the illustrative costs of SSM and restoration practices.

- ***It has not been possible to map between the implementation of SSM practices, restoration and remediation measures, to a change in descriptor:*** leading on from the point above, data and information is not available which can be used to map from the implementation of a given (or a set of) SSM practices, restoration and remediation measures to a defined change in one or more soil health descriptor. As such, it is not possible to show what effect implementing these measures under the Options will have on the achievement of the descriptors, and hence to define a package of practices with associated costs and benefits that would achieve good soil health.

  To mitigate this limitation the assumptions underpinning the selection of sample practices were clearly set out and the soil health indicators on which they will impact. In the estimation, the extent of application of the measures to soils where they will be appropriate was refined and likely work towards the achievement of good health in those soils – e.g. for cover crops, these are assumed only applied to agricultural land left bare over winter.

- ***Potential synergy effect between building blocks***: Some SSM practices may also lead to the improvement of soil health, and consequently could contribute to the restoration of soil which is a positive synergy between the building blocks. That said, when it comes to impact assessment, such synergies also result in overlaps between the impacts of options under different building blocks, and additional complexity in the allocation of impacts to specific building blocks. Data and methods are not available to define precisely the overlap and allocate specific impacts to specific building blocks. Throughout the analysis, care has been taken to highlight where these overlaps occur, and also in the aggregate analysis to focus on the likely combined, overall benefits.

  To mitigate this limitation in the analysis it was set out clearly where these overlaps occur, and ultimately present an aggregate assessment of the benefits of the whole SHL package for comparison to the costs.

1.4.2 Summary assessment

These and other limitations have meant that the impact analysis was built on a partial evidence base and complemented by expert judgement and opinion. A qualitative analysis framework inspired in both Multi-Criteria and Cost-Benefit Analysis (as per Tools #57 and #63 of the Better Regulation Toolbox) was employed to help summarise and convey the advantages and disadvantages, and compare between, the different options under each building block. Five steps were followed.

Step 1: Developed a **qualitative scoring framework** on a (-3)-to-(+3) point scale for options. The scoring reflects the direction (positive or negative) and magnitude (weakly to strongly, limited or unclear). The scale is presented in the table below.

Table 1-1: Coding used to present expected impacts

+++	**Very significant direct positive impact (e.g. For 'Impact on soil health' this equates to complete restoration of all soils to good health, or complete remediation of all contaminated sites)**
++	Significant direct positive impact
+	Small direct positive impact
(+)	Indirect positive impact
+/-	Both direct positive and negative impacts, and balance depends on how implemented
0	No impact or only very indirect impacts
(-)	Indirect negative impact
-	Small direct negative impact
- -	Significant direct negative impact
- - -	Very significant direct negative impact

All options have been assessed on this basis against nine categories representing effective, efficiency and coherence (and risks of implementation):

- Effectiveness: (a) Impact on soil health, (b) Information, data and common governance on soil health and management, and (c) Transition to sustainable soil management and restoration
- Efficiency: (a) Benefits, (b) Adjustment costs, (c) Administrative burden and (d) Distribution of costs and benefits - this considers how narrowly or broadly the costs or benefits are distributed (e.g. where costs fall more so on a more limited cohort of actors – such as few Member States – the indicator is attributed

a more significant score than where costs are spread more evenly -e.g. across all Member States).

- Coherence – highlighting the synergies or not with options under other building blocks, and/or with the broader policy environment
- Risks for implementation.

The range for each indicator was set to define the maximum positive and negative effect for that indicator specifically. All options across all building blocks have been assessed using the consistent scale for each indicator, to ensure consistency and comparability in the assessment across building blocks and add-ons. As such, the scoring inherently captures a comparative, relative assessment across indicators. Albeit as the assessment was qualitative, an iterative process with a centralised re-calibration exercise was always expected and planned from the start.

Step 2: A team of experts mapped and assessed impacts of options and the scoring across the indicators, each expert covering between 3-6 options across the building blocks.

Step 3: A **re-calibration exercise** was carried out after every iteration from the team of experts.. This was to ensure that the ratings were internally coherent and challenged constructively. The scope of the options and evidence of the likely scale of impacts were used to test and validate the relative position of each measure in terms of their economic, environmental and social impacts.

Step 4: A **policy/ impact aggregation exercise** was implemented upon each step in the delivery of the assessment of options and iteration of the Assessment Sheets. As qualitative and quantitative analyses were carried out for individual option, updated analysis was reflected on and within (where appropriate) the indicator scoring.

Step 5: **Validation and quality assurance** activities were also taken forward with a separate team of experts.

2 SOIL HEALTH AND SOIL DISTRICTS (SHSD)

2.1 Overview

2.1.1 Building block outline

The aim of this building block is to determine the descriptors and descriptor ranges of soil health and to establish soil districts in each Member State. The building block will determine the biological, physical, and chemical status of soil using soil health descriptors and ranges and will establish areas (or 'districts') in Member States, in which representative soil samples are taken, and determine to which extent those areas have healthy or unhealthy soils.

2.1.2 Problem(s) that the building block tackles

The overarching problem is that soils in the EU are unhealthy and continue to degrade. The key problem this building block addresses is ***sub problem A*** from the Intervention Logic: Information, data and common governance on soil health and management is lacking or incomplete. This problem occurs due to a range of reasons:

- No agreed method or set of parameters and ranges to assess soil health
- Lack of technological solutions, insufficient digitisation, gaps in research and innovation, etc.
- Complexity of the problem is sometimes difficult to grasp
- Lack of awareness of the importance of soil health
- Focus on short-term benefits without taking account of future costs and income related drivers.

2.1.3 Baseline

Soil health and districts are yet to be defined as it is currently not explicitly written in policy. Although some indicators are monitored across different Member States and there are sets of indicators identified in research programmes at EU level (e.g. through the LUCAS survey), there is no one set of criteria that have been developed and adopted, looking universally at soil health, for the purpose of achieving soil health. There are standard methodologies for the measurement of most soil parameters. LUCAS soil uses them, but this is not systematically the case in all MS methodologies.

Table 2-1: Policies influencing the baseline for SHSD options

Policy	Relevant Component	Relevance to Soil Health and Districts
Industrial Emissions Directive (IED)	A baseline report is used to assess soil contamination caused by an installation's activity and where 'significant' pollution has been caused, the operation must take the necessary steps to return the soil to baseline level or, alternatively buy additional permits.	The threshold/determinates used to classify what 'significant soil pollution' is, could be associated with establishing the determinants for 'healthy' and 'unhealthy' soil.
Common Agricultural Policy (CAP)	CAP Indicators take into account specific characteristics, including soil and climatic condition, existing farming systems, land use, crop rotation, farming practices, and farm structures, Member States shall define, at national or regional level the minimum requirements for GAEC. GAECs 5, 6 and 7 refer to soil standards which farmers must comply with.	Defining the requirements for GAEC is relevant to defining status of soil health using soil health indicators.
European Statistics	Eurostat carries out a detailed overview of Agri-environmental indicators to	Soil erosion (mean tonnes per ha per year), soil quality, soil cover and land

Policy	Relevant Component	Relevance to Soil Health and Districts
	monitor the integration of environmental concerns into the CAP at regional, national and EU level.	use change are all included in the 28 Agri-environment indicators. In an agri-environmental context, soil quality describes: • The capacity of soil to biomass production • The Input-need to obtain optimal productivity • The response of soil to climatic variability • Carbon storage, filtering and buffering capacity. (Other Agri-environment indicators include irrigation, tillage practices and mineral fertiliser consumption)
Environmental Liability Directive (ELD)	Under the ELD, environmental risk is not covered in the definition of land damage as it is restricted to 'significant risk to human health being adversely affected'. However, some Member States use a more comprehensive definition which includes a risk to the environment or a risk of violating certain limit values of pollutants.	Defining damaged/unhealthy land is in line with the establishment of ranges and determinants of soil health
	The ELD addresses soil contamination which has reached a certain threshold and poses a significant risk to human health (risk to the environment is not considered).	Establishing threshold values, outside of which, soil is classified as contaminated
	The definition 'significant risk of human health' with regard to the significance thresholds for land damage is narrow (according to the ELD evaluation 2016). Therefore, the ELD impact on the protection of soils may be limited.	Defines 'land damage', even if the threshold and range for 'land damage' is narrow and a more precise determination is needed
Environmental Crime Directive	To address environmental crime, the Environmental Crime Directive provides guidelines for concepts of: • Substantial damage • Activity likely to cause damage to air, soil or water quality or to animal or plants • Quantity negligible or non-negligible.	Establishing the determinants and threshold of activity causing damage to soil
Nitrates Directive	Designation of Nitrate Vulnerable Zones (NVZs)	Designation of districts to action management practices
	Establishment of thresholds applicable to NVZs	Establishment of thresholds/ranges to determine 'healthy soil'
EU Soil Strategy	The EU Soil Strategy for 2030 sets out a framework and concrete measures to protect and restore soils. The objectives of the EU Soil Strategy for 2030 is to achieve healthy soils by 2050	The EU Soil Strategy has defined soils as healthy when they are in good chemical, biological and physical condition and therefore able to provide as many of the ecosystem services as possible (food production, absorb, store and filter water, provide basis for life, act as a carbon sink etc.).
Floods Directive	Production of flood hazard and risk maps to action flood management plans	Designation of districts to action management/restoration practices
Water Framework Directive (WFD)	The WFD is managed through river basin management plans. A plan must be developed for each river basin district.	Designation of districts to action management/restoration practices
Ambient Air Quality Directives (AAQD)	The EU AAQDs mandates EU Member States to divide their territories into zones and agglomerations to assess air quality	Designation of zones in Member States for the purpose of quality assessment and management
Soil Mission (Horizon Europe)	A Soil Deal for Europe	In 2021, EUR 12 million was dedicated to soil monitoring and research on soil health indicators

Policy	Relevant Component	Relevance to Soil Health and Districts
EJP (European Joint Programme) Soil[445]	EJP SOIL is a 60-month European Joint Programme Cofund on Agricultural Soil Management to develop knowledge, tools and an integrated research community.	EJP Soil has 9 projects relating to Soil Health and some include the identification of indicators. For example, the aim of the SIREN project is to make an inventory of indicator systems for assessing soil quality. Similarly, the MINOTAUR project aims to identify and select relevant and functional indicators specifically for soil biodiversity.

2.2 SHSD – Option 2: Member States define health ranges and districts

2.2.1 Description of option and requirements for implementation

All options under the Soil health and soil districts (SHSD) building block contain:

- EU to define a minimum list of descriptors to define soil health which contain core soil descriptors and set these in law. The provisional minimum list (likely to be updated) contains:
    - Land take and soil sealing- net land taken and imperviousness area
    - Acidification- pH (all soils)
    - Topsoil compaction- Bulk density in topsoil (all uses)
    - Subsoil compaction- Bulk density in subsoil (all uses)
    - Loss of soil capacity for water retention- soil water holding capacity (all uses)
    - Loss of carbon- Soil Organic Carbon (SOC) (all uses except forests)
    - Soil erosion and eroded soils- soil erosion rate/risk
    - Salinisation- Electrical Conductivity dS/m (measurement only in dry and coastal areas)
    - Excess nutrients: phosphorous- Extractable phosphorus in mg/kg (all uses)
    - Excess nutrients: nitrogen- Nitrogen in soil (all uses)
    - Soil biodiversity loss- potential soil basal respiration, or alternative soil biodiversity indicators to be defined by Member States such as: Metabarcoding of bacteria and fungi and animals; Abundance and diversity of nematodes; Microbial biomass (all uses); Abundance and diversity of earthworms (cropland)
    - Soil contamination- concentration of heavy metals (all uses), concentration of a selection of organic contaminants defined by Member States
- EU to set obligation for Member States to establish soil districts. Member States will have to appoint Soil District Authorities responsible to achieve healthy soils in the district.
- EU to define the conditions, bearing on all descriptors of the 'minimum list' that are within the range indicating 'good' health status, for soil at a sample point to be defined as in 'good' health. It is assumed that the condition will follow the principle 'one out - all out', i.e. it if one soil health descriptor of the 'minimum list' lies outside of the range of values defining 'good' health, then the soil at that sampling point is considered as 'unhealthy'.
- Requirement to appoint an authority for each soil district, with responsibility regarding the setting up and follow up of the relevant processes.

[445] The 24 participating countries include France, The Nederlands, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey & United Kingdom

Option 2 also includes the following specific elements:

- Member States to define descriptor range of values to rate soil health status as being 'healthy', it is assumed that Member States will do this for all descriptors in the 'minimum list'.
- Soil districts to be established entirely by Member States without common EU criteria.

The majority of stakeholders recognise the value in defining soil health descriptors and thresholds: several highlighted the benefit that these would play in triggering action as soon as a threshold or range is crossed. In response to the OPC, stakeholders agreed that a number of different chemical, physical, water-related and biological indicators would be either reasonably or very effective to assess soil health, agreeing that a combination of indicators is required to do so effectively. Moreover, several stakeholders highlighted the importance of reflecting ecosystem services and biodiversity, given their importance in addressing the functioning of soils and its services and the minimum levels required to maintain these services. Stakeholders also noted that there has been significant research and consideration of what constitutes soil health over the years, and as such there is a body of evidence already available which can be drawn on. Chemical, physical and biological soil health descriptors must be established with threshold/range values to be able to classify which soils are 'healthy' and which soils are at risk[446] and these threshold/range values must be determined taking into consideration the differences in climatic condition, soil type and land use.[447]

With regards to soil districts, stakeholders highlighted the importance of a risk-based approach when establishing soil districts as risks will differ per soil district. Furthermore stakeholders also noted that it would be important to ensure flexibility with regards to the size of soil districts which is considered important from a policy perspective. In addition to this, stakeholders generally believed natural borders should define soil district boundaries.

2.2.2 Assessment of impacts

Economic – Option 2

The establishment of soil health descriptors and districts across the EU acts as a facilitating step to allow the implementation of subsequent effective soil health management and restoration.

Under Option 2, the research required by each Member State to define the soil health descriptors and the thresholds/ranges for a select set of descriptors, as well as identifying districts (taking into account soil type, land use and climatic condition) would be progressive and therefore have a positive and significant impact on the provision and use of information for further research and development. However, this research will have an economic impact as ***administrative burden***. This was reiterated by stakeholders who emphasised that there is a lack of knowledge surrounding the physical and biological aspects of soil health. However, there is already a budget of €12million within the Soil Mission dedicated to soil health definition which has the potential to reduce the

[446] EEA (2022) Soil monitoring in Europe - Indicators and thresholds for soil quality assessments. https://www.eea.europa.eu/publications/soil-monitoring-in-europe-indicators-and-thresholds

[447] Caring for soil is caring for life - Ensure 75% of soils are healthy by 2030 for food, people, nature and climate

administrative costs for Member States while it places uncertainty around the additionality of the innovation benefit. Indeed, the JRC notes that constant research, development and communication with experts is required to harmonise the understanding and reporting of the soil health indicators.[448] Appointing a Soil District Authority will have an economic impact. The cost in doing this has been included in the development of administrative burdens found in section 6.

Regardless of whether Member States or the European Commission determine the soil districts, it is important to recognise that some Member States will have more soil districts than others due to the varied climate, soil type and land use within each Member State. Therefore, depending on the complexity of these parameters, some Member States will have to invest more effort than others in identifying their soil districts and allocating governance responsibilities. To estimate the order of magnitude of costs of soil district, the number of soil districts is assumed to be more than the number of regions but less than the number of provinces (hence between 242-1,166) and may be allowed to cross borders (which may increase complexity). This detail from the EU will put varying amounts of economic impact on the different Member States depending on the number of districts they are expected to establish.

Under Option 2, compared to the baseline, there will be a greater administrative burden for Member State public authorities in terms of staff numbers, allocation, and time due to the complexity and research required to establish and define appropriate soil districts, soil health descriptors and ranges without any common criteria. Costs of establishing soil districts and soil health ranges may differ between Member States and cost more for those which have a greater variety of soil types, climatic condition and land use. Higher costs could be incurred by Member States who choose to define soil districts at a more granular level due to the increase in complexity – as such there may be an incentive for Member States to select a simpler district allocation, in particular where this better aligns with existing governance structures (e.g. establishing districts as administrative units).

There will be a greater cost for Member States to determine soil health indicators and districts for those who have not yet started to develop initiatives in this area - across the EU, the availability of soil information varies.[449] An example of a Member States who has information that can be used to help establish soil health districts and descriptor ranges include Lower Austria’s current soil monitoring activities which provide information required to calculate soil health indicators, however this is limited to information on the following soil threats soil sealing, soil erosion, soil contamination and soil acidification. One Member State stakeholders explained however that they could take information/data from national norms, assessment schemes, international literature and European documents related to the consultation process for a European Soil Health Law to establish descriptor thresholds. Similarly, another Member State stakeholder stated that soil health indicators are already available, and Norway currently has a normative list of values for 58 substances that act as a threshold to define soil as contaminated. Estonia has established specific indictors for monitoring agricultural soil and land degradation processes and include total N (g/kg), total organic carbon (g/kg), Mass of organic layer (kg/m^2), pH(CACL2), pH(H2O) Bulk density (kg/m^3) and many more using the International Organisation of Standardisation (ISO) methodology. A

[448] LUCAS 2022
[449] LUCAS top soil

detailed mapping of which soil health descriptors have been tested in each of the Member States can be found in the table in section 6. On the other hand, some Member States do not have as much information to establish soil health descriptors and ranges/thresholds, for example one stated further discussion and research is required to develop ranges and threshold values for some soil health descriptors.

Evidence and information to support the estimation of administrative burdens is limited, but illustrative estimates have been developed based on expert judgement. The EC will be investing more time in developing soil health descriptors and estimates it will invest 1 FTEs for 1 year to do so. Where Member States are left to develop their own thresholds, each Member State would individually have to invest resource to do so. Assuming a similar level of resource to the EC is replicated instead across all 27 Member States, this option would incur an upfront administrative burden of EUR 2.7 m assuming cost per FTE of EUR 50,000 per annum (although noting that there may be some learning across Member States, and not all Member States may investigate thresholds for all descriptors, both of which would reduce the additional burden).

In addition, Members State would have to invest resource to establish soil health districts. It could be assumed that a similar amount of resource would be invested by each Member State to establish soil health districts, in addition to commissioning a small external study to support their development. This could add an additional EUR 4.73 m in administrative burden. Total administrative burden could be around EUR 121,000 upfront for EC, and EUR 4.86 m for Member State competent authorities.

Table 2-2: Total administrative burden across SHSD options

Option number	**EC - One-off costs**	**EC - Recurrent costs**	**MS - One-off costs**	**MS - Recurrent costs**	**Other - One-off costs**	**Other - Recurrent costs**	**TOTAL - one off**	**TOTAL ongoing**
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 2	8,100	-	330,000	-	-		330,000	-

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

Landowners and farmers will not be directly affected as this soil health and district building block refers to definition. That said, as the soil health descriptors will determine which actions/measures are required for sustainable soil management or/and restoration of soils, it will therefore also have a knock-on, indirect ***adjustment cost (public authority budgets)*** of implementing these actions also (considered in the SSM and REST options).

Investment in research ***(Innovation (productivity and resource efficiency); research (academic and industrial)***) would be required to define the ranges and thresholds for each soil health descriptor, which would have an overall positive innovation effect. However, there is already a budget of €12 million within the Soil Mission dedicated to soil health definition which has the potential to reduce the administrative costs for Member States to establish soil health districts and definitions, which places uncertainty around the additionality of the innovation benefit but also the additional administrative burdens presented above.

Environmental – Option 2

The process of defining soil health indicators and soil districts will not have a direct impact on the environment. However, defining soil health descriptors, thresholds and districts is a critical facilitating step necessary to determine the action and measures needed to achieve soils in good health, and hence improve soils and surrounding environment. This, along with other links to building blocks, is discussed further under links/synergies below. Whilst defining soil health indicators and soil districts alone will not have a direct impact on the environment, soil itself has a direct and significant impact on a wide range of ecosystems and the services they provide. Examples of these ecosystems and services include carbon sequestration, air pollution regulation, water quality and availability, biodiversity and prevention and/or limitation of natural hazards such as flooding.

Social – Option 2

Defining soil health descriptors can have a positive and direct impact on the ***provision and use of information*** for further research and development, academic projects, validation of modelling outputs, input parameters for modelling of soil processes, fertility and erosion studies, remote sensing analysis and ecosystem service assessments.[Error! Bookmark not defined.] Defining soil health descriptors has the ability to contribute to future policy needs as healthy, functional soils are linked to many other environmental regulatory areas (e.g. climate law), hence clarity on definitions of healthy soils could better facilitate the design and delivery of linked regulatory areas.

Defining soil health descriptors and districts does not have a direct impact on ***food safety, food security*** and nutrition (one of a range of ecosystem services that soil supports, other examples are mentioned in the '*Environmental*' section above). However, defining and understanding the indicators which determine what makes soil 'healthy' helps us to understand soil potential and capacity to fulfil various societal needs such as food production and food security.[446] Whilst the act of defining soil health descriptors and districts does not have a direct impact, there is an indirect impact on social well-being as soil health descriptors will be used to measure key degradation and soil health descriptor thresholds will define a loss of ecosystem service.

2.2.3 Distribution of effects

Administrative burden will fall on either Member State Competent Authorities (Option 2), a combination of these authorities and the European Commission (Option 3) or all burden will fall on the European Commission (Option 4).

Under Option 2, the direct costs (administrative burdens) of the option will fall only on Member State Competent Authorities. There will be a greater cost to Member States to determine soil health indicators and districts who are already lacking in soil information as, across the EU, the availability of soil information varies.[Error! Bookmark not defined.] Member States who have already begun to develop soil health descriptors would face less additional costs than Member States who have not. This is supported through the EJP SIREN project which found that whilst most of the 20 Member State countries involved theoretically take soils into account in the ecosystem services assessments by characterising soil functions, the use of soil quality monitoring data to assess soil functions and ecosystem services is not widely taken up.

Defining good soil health plays a key role in delivering inter-generational equity. As a fundamental building block of improving soil quality, this building block has a critical role to play in delivering the environmental, social and economic benefits of healthy soils and avoiding the deterioration of soil health which will have a greater burden on future generations. Moreover, providing meaningful information on the state of soils is important for EU citizens to understand the role of soil for the common good and the ecosystem services they provide, whilst also providing the information required to inform citizens on the health of soil on a particular site (delivered through the soil health certificate (CERT)).

Otherwise, there is no significant driver of a differential impact between different stakeholders and stakeholder types – e.g. between rural and urban areas.

2.2.4 Risks for implementation

Where districts are set on the basis of location-specific parameters, some districts may contain several areas with common parameters, but which may be somewhat geographically dispersed. This raises a challenge as to whom would be responsible for these districts. Defining clearly the governance and responsibility for each district is critical to the effective definition of thresholds and undertaking of monitoring and restoration under linked building blocks.

Option 2

There is widespread recognition across stakeholders that the definition of soil health should take into account pedoclimate conditions and land use. Hence Option 2, in allowing Member States to define ranges and thresholds, perhaps provides a benefit in the greater flexibility allowed to define ranges and thresholds which reflect differences in pedoclimatic conditions. Stakeholders broadly agree that districts should be set on the basis of location specific factors, in particular climate, soil type and land-use, and hence allowing districts to vary in terms of size would be beneficial. Stakeholders also noted a precedent for the variation in size in the Groundwater Directive, where the size of bodies - and the consequent number in each Member State - varies significantly). In response to the OPC ‘At the level of a zone homogeneous for pedo-climatic conditions and use’ and ‘At the level of a zone homogeneous for pedo-climatic conditions (whatever the land use)’ together formed the most common response (14% and 8% respectively, together comprising 22%) in response to the spatial level at which soil health should be monitored. This was re-iterated by expert stakeholders where several noted that reference values should vary by climate and soil type.

However, this flexibility also presents a risk that there will be a lack of consistency between Member States’ soil health descriptor thresholds and ranges. This variability would make comparison difficult. This variability could come in: soil district size, number and how they are defined, the particular soil health descriptors for which thresholds are defined and the specific thresholds or ranges defined. This risk is accentuated by the link between this measure and the REST building block. Member States will have an obligation to restore all soils to good health by 2050, and as such there is an incentive to define laxer definitions of soil health descriptor ranges under the building block SHSD Option 2. Indeed stakeholders noted thresholds should be set that motivate actors to take action – i.e. they need to be achievable, but also understandable and easy to measure.

Establishing soil health districts on the basis of pedo-climatic conditions and land use can be costly and complex. As such there is a risk that there will be a lack of true representation of soils when Member States determine the soil districts as some may choose a simpler method to set soil districts rather than determining a number of districts which represent the differences in soil type, climate, land use etc. within each Member State. It was stated in the expert group that if establishing districts is left to the Member States, they may be set on a different basis, for example administrative units due to implementation and administrative costs and therefore not represent the Member states climatic condition, land use and soil type. Indeed, through the various engagement activities Member State stakeholders noted several alternative options for defining districts (potentially highlighting that Member States may adopt different approaches), including: a risk-based approach to defining soil districts to reflect that risks will differ across soil districts (but which may not produce a comprehensive nor consistent mapping of soil health); the historic condition of the soils, and natural geographical borders. Defining soil districts by natural borders was considered by stakeholders important to determine ranges of descriptors to define what the health is and the action to undertake: geology (and soil types), climate, land use / land cover, chemical contamination if needed. However, stakeholders also highlighted that defining districts on the basis of administrative units would be counterproductive and they would not adequately reflect variation in climatic condition, soil type and land use.

If defining soil health ranges are left to Member States, as set out in Option 2, there is a risk that some Member States will invest more than others in developing the system to establish the districts and determine the ranges. Moreover, given the technical complexity in establishing what constitutes 'good health', there is also a risk that some Member States do not have access to the necessary skills and expertise to robustly defining soil health ranges, whereas others will call separately on a small pool of experts to help. This risk of investment variation and differences in skill and expertise would have a direct impact on the robustness and completeness of the soil health descriptors, leaving some Member States with a weak soil health definition which does not effectively address soil degradation.

2.2.5 Links /synergies

Defining soil health descriptors is crucial to be able to assess the impact of human activity and determine the required actions/measures to either restore unhealthy soils to a healthy status or maintain the good health of the soil through sustainable soil management practices. Defining soil health descriptor ranges and thresholds is necessary to identify which sustainable soil management practices (SSM) are effective to keep soils within the values of a 'healthy' range for each soil health descriptor. Similarly, without defining soil health descriptor ranges and thresholds, it would not be known what values to aim for when using soil restoration practices (REST). This is reiterated by stakeholders who stated that 'The descriptors and ranges will be used for: (1) keeping the soils qualified as 'healthy' in that state, (2) enforcing the obligation for Member States to act on soils qualified as 'unhealthy''. Hence there is a critical link between the option selected under this building block, and the SSM and REST building blocks – in particular, the thresholds selected here will define the area of land deemed 'unhealthy' and requiring restoration. Thresholds and range values are necessary to understand the minimum standard of soil health as exceedance of this causes a critical loss of ecosystem services and classifies soils as 'unhealthy'. Establishment of soil health thresholds and range values are vital in determining when areas/soils require restoration practices over sustainable soil management practices, and the urgency and quantity of restoration required following the exceedance of the threshold for 'healthy' soil (link to Restoration building block). This was reiterated by stakeholders who stated that 'ranges will define the ambition and the amount of work to be done to restore soil health'. Stakeholders also highlighted the benefit of thresholds as 'trigger values' for each soil health descriptor which would then require action when the threshold was crossed.

The impact selecting thresholds and ranges has on the size of areas of land defined as healthy or otherwise against different descriptors and thresholds, is explored in the Information Box in Section 1.6.3.

Defining soil districts and soil health indicators is essential for environmental planning and the monitoring (MON) of soils in these districts.**Error! Bookmark not defined.** as it defines the indicators against which data needs to be collected and at what resolution. Similarly, the soil health descriptors defined under this building block will be used in the soil health certificates and if these cannot be defined (or aren't robustly defined), this undermines the effectiveness of CERT2. This is also true for defining soil health on soil passports (PASS), which also require clearly defined information on healthy soils.

There is a variance in the coherence of different options under SHSD when combined with different options under other building blocks. Option 2 is likely inconsistent with monitoring, sustainable soil management and restoration Options 4 as it would be challenging to fully harmonise monitoring and action at EU level where descriptors and descriptor ranges differ by Member States and instead may result in mandating action which does not work towards 'good health' as defined for specific Member States.

The Soil health and Soil district building block, will be influential in the size of economic, environmental and social impacts of other building blocks and in particular the restoration building block.

2.2.6 Opinions of stakeholders

Opinions received on the obligation to set soil districts and their authority as well as a minimum list of soil health descriptors are presented below, for each EU MS and further major stakeholder types. Information was extracted from written feedback received from MS and other stakeholders.[450] EU MS generally agreed on districts being based on bio-geographic aspects. Thereby, they mostly found MS to be the most suitable actors to define those. Random statistical sampling was also perceived as a possible option. A general consensus also existed regarding a need for certain unity of soil health descriptors across the EU. However, MS emphasised that the descriptors cannot be standardised since 'health' varies, depending on the type of soil and its use. Suggestions included common minimum thresholds or an average score out of values chosen from a set by MS. The majority of MS emphasised the need for flexibility for MS.

Table 2-3: Overview of stakeholder input on SHSD

	Obligation to set soil districts and their Authority	Minimum list of soil health descriptors

[450] Note that opinions from OPC position papers for civil society and research and academia stakeholders are not synthesized here. Please see the synthesis of stakeholder consultations for more information on the views of these stakeholders.

Austria	• For a general SHL, neither a national nor a parcel level is granular enough; • Administrative level is not practical and hardly feasible due to administrative heterogeneity; • Establishment of soil districts is appropriate, but these should be defined by MS, according to biogeographic regions (rather than administrative)	• Core set of contaminants can serve as a starting point and allow for knowledge exchange; • Their definition on EU-level is unsuitable (should be defined at MS level); • Minimum thresholds needed but related to huge monitoring efforts; • National averages are inappropriate e.g. a combination of EEA parameters could be suitable, covering specificities of different land uses.
Belgium	The application of 'homogenous units' preferred, combined with management scales.	• Common definition across MS needed; • Common specific values can be tricky since soils differ across regions; • Sum of several parameters could serve as threshold scores; • Should be defined at MS level.
Bulgaria	No answer provided	No answer provided
Croatia	No answer provided	No answer provided
Cyprus	No answer provided	No answer provided
Czechia	The Research Institute for Soil and Water Conservation provides soil monitoring in the CZ. Observes pollution of agricultural soil, focused on risky elements and persistent organic pollutants, evaluates and judges regional environmental load with pollutants, including the related geographical information system, using Homogeneous and Statistical units.*)*	Easily measurable indicators applicable to the performance of public administration should be defined. The parameters would be different according to soil types and land use, for agricultural land, for forest land, for other land, including land in urban areas.
Denmark	No answer provided	No answer provided
Estonia	No answer provided	No answer provided

Finland	• Parcel level is too narrow for large countries; • Administrative level covers too many different land use and land types; • District level allows flexibility for MS; • Defined areas should be large and include hot-spot areas; • Districts' definition based on soil natural characteristics; • Randomised sampling also possible.	• Gradual increase of monitoring coverage and related relevant indicators; • MS should decide on descriptors relevant to them.
France	No answer provided	• Minimum list of soil contaminants and setting their threshold values rejected. (Risk-based approach considering land use preferred).
Germany	• Administrative level meaningless since it is based on average values; • Statistical units the most preferred since MS are responsible.	• Too much effort if to be defined by MS; • Varies depending on soil type.
Greece	No answer provided	No answer provided
Hungary	• A common "Soil District Manual" should be developed to ensure that MSs apply the same methods and provision for determining districts and zones	No answer provided
Ireland	Districts could be defined by MS with homogeneous characteristics (e.g. concerning land use and geoclimatic conditions). Geological Survey Ireland applied this approach, could be extended.	If statistical units are to be used, then a minimal number of those should be determined. As soils and soil health are principally a function of the underlying geology, age, climate, and use, it would seem that the best unit of health determination should be based on the distribution of the main soil types in a nation (which is influenced by the functions listed).
Italy	• Defining soil health based on 'sites' is not optimal since it can cover different soil types; • Districts could simplify	• Soil health cannot only be explained by soil contamination (e.g. excessive salination etc. also relevant).

	reporting; • Should be identified by MS.	
Latvia	No answer provided	No answer provided
Lithuania	Zoning might be sufficient for EU/national level but farming level needs parcel-approach.	Scientifically speaking, it should contain several ranges. However, this goes along with high bureaucratic efforts.
Luxembourg	• The definition of 'sites' should be based on the pollution itself; • Zoning should consider main land use type; • Should be set by MS. *(CMS)*	• Soil health definition depends on land use; • MS should be able to include further descriptors if needed; • Link to dangerous substances not recommended since it would not be complete. *(CMS)*
Malta	No answer provided	No answer provided
Netherlands	• Responsibility with MS (NL *1111202*)	• Start set of descriptors should be scientifically proven (NL *11112022*); • Descriptor ranges to be defined by MS (NL 11112022); • Horizontal approach towards risk assessment methodologies but autonomy for MS to define thresholds; • Soil health defined by the ability to provide ES.
Poland	No answer provided	No answer provided
Portugal	The definition of homogeneous methodology is crucial.	• Predefined set of thresholds for chemical, biological and physical parameters on EU level demanded; • Ranges to be defined by MS.
Romania	Regarding use of homogenous units, this should be avoided. Instead, the reference intervals depending on the type of use (agricultural, forestry, pastures, etc.) should be used.	List on EU-level supported but with flexibility for MS to set thresholds.
Slovakia	No answer provided	No answer provided
Slovenia	No answer provided	• Defined by the level of quality of an ES provided; • Set of parameters for all land uses should be given.
Spain	Using pedo-climatic or litho-climatic zones or units was suggested. A possible definition for soil litho-climatic unit could be: a geographical domain with a minimum extension, which can be mapped at a given scale,	• Common list on EU level should be simple and economically feasible; • Depends on land use type.

	with homogeneus lithologic features developed in a given climatic zone.	
Sweden	• Soil health is a MS topic	• Soil health is a MS topic
Other public authority	• Landscapes should define districts; Responsibility with MS.[451]	• Descriptors should start simple and take a phased/tier-based approach.[452]
Farmers	No answer provided	No answer provided
Foresters	No answer provided	No answer provided
Land owners / land managers	No answer provided	No answer provided
Industry (businesses and business associations)	• The need for defining soil districts depends on how data is supposed to be aggregated; • Building zones based on scientific characteristics and land use instead of administrative boundaries.[453] • Definition based on soil type, not land use.[454] • Definition based on land use.[455] • Definition based on ecosystem service provided.[456] • Flexibility should be granted to MS to consider already existing soil legislation.[457] • Should be defined by MS. n=2[458] • District definition should	• Descriptor should consider the acceptable risk related to the type of land use. n=5.[460] • Indicators should be easy to measure and economically feasible. n=2[461] • Ranges for descriptors are not feasible because of the high number of different soil types.[462] • Ranges should be district-specific. n=2[463]

[451] Common Forum
[452] Common Forum
[453] Cefic
[454] NICOLE
[455] ICL
[456] IFOAM
[457] Cefic
[458] Eurometaux, NICOLE
[460] Cefic, Concawe, Eurometaux, ICL, OCP Group
[461] Comite Champagne, Concawe
[462] Cefic
[463] Comite Champagne), Concawe

	happen on local level.[459]	
Civil society (NGOs)	• Registered parcel/plot/site more adequate than soil districts.[464]	No answer provided
Research and Academia	• Definition of soil districts necessary to make descriptors applicable to something; Responsibility with MS.[465]	• The list established by SIREN should be used for descriptors; Descriptors should start simple and take a phased/tier-based approach.[466]

Summary assessment against indicators

Option 2 would be most suited to Member States which already have knowledge regarding the health of their soils and how this is determined and would enable action to be implemented without delay. However, knowledge is varied between Member States and defining soil health districts and soil health descriptor ranges at this level directly impacts upon other building blocks in terms of their general feasibility and choice of Option and could be considered incompatible with other building block Options. Moreover, Option 2 would likely result in a lower benefit in comparison to Options 3 and 4 as it would create a variable system which is not comparable between Member States. For example, there would be variation in Soil district characteristics and the range of soil health descriptors for which thresholds are defined. On the assumption that common criteria could prevent Member States from defining simpler solutions with less effort, Option 2 has the potential to result in a lower admin cost in comparison to option 3 but higher than Option 4. However, there is a higher probability that the technical input from the EC under policy Option 3 will result in lower administrative burden in comparison to Option 2 as the technical complexity placed on each Member State is reduced. In addition to this, the highest risk of Option 2 is the general lack of consistency between Member States and that soil health districts will become administrative units.

Table 2-4: Overview of impacts of option 2

Effectiveness	**Impact on soil health**	(+)	No direct impact, but is critical foundation for action to achieve good soil health, and will influence benefits achieved through SSM and REST
	Information, data and common governance on soil health and management	++	Key benefit, in particular through appointment of Soil District Authorities. But benefit curtailed relative to Option 3 given risks to implementation.
	Transition to sustainable soil management and restoration	(+)	No direct impact, but is critical foundation for action to achieve good soil health
Efficiency	**Benefits**	++	Improvement of data, information and governance key benefit
	Adjustment costs	0	No direct impact, but is critical foundation for action to achieve good soil health, and will influence costs of action under SSM and REST
	Administrative burden	-	Low administrative burden (< EUR 1m upfront or ongoing)
	Distribution of costs and benefits	-	Burden to define descriptors falls on Member States – some have already begun to take action whereas others have not.

[459] Concawe
[464] ICNF et al.
[465] INRAE
[466] INRAE

Coherence	+/-	Option less coherent with some options under other building blocks
Risks for implementation	--	Highest risk of variance across Member States in the approach to defining thresholds and districts; risk of limited soil health expertise across Member States to define thresholds and districts

2.3 SHSD – Option 3: Some common EU descriptor ranges and Member States define districts with common criteria

2.3.1 Description of option and requirements for implementation

Option 3 contains several specific elements:

- EU defines thresholds or range of values to rate soil health status as being ‘good’, for each soil type, climatic condition and land use, for the following limited set of descriptors in the ‘minimum list’. A provisional set of thresholds (likely to be updated) have been developed by the EU for the descriptors on the minimum list (this does not cover all indicators on the minimum list) as presented in the table below.
- Soil health ranges are developed by the EU for a selected set of parameters, based on available scientific knowledge. The remaining four descriptors are to be monitored by Member States
- Soil districts to be established by Member States, following a set of mandatory criteria on homogeneity defined by the EU (i.e. homogeneous pieces of land, in terms of pedo-climatic conditions, land capability and land use), and bearing upon: maximum share of surface allocated to land uses other than the dominant land use in the soil district; maximum standard deviation in the values taken by the descriptors of the 'minimum list' between samples taken in the soil district (using the sampling procedures defined in the thematic area MON on monitoring).

In a response to the feasibility for the EU to set common sampling/strategy processes for different soil health indicators, one stakeholder has detailed the importance of classifying soil health indicators stating they must be ‘context specific’ and reflect locality and that the JRC has a methodology for soil districts and soil health per district by SOC/clay ratio which must now be made operational.

Table 2-5: Provisional set of descriptor thresholds

Aspect of soil degradation	Selected soil descriptors	Ranges for soil health	Derogations (from both monitoring and achieving ranges by 2050(#))
Loss of soil capacity for water retention	Soil water holding capacity (all uses)	Threshold to be set by MS for each soil district, at a satisfactory level to mitigate the impact of extreme rain or drought, accounting as well for artificial areas (EU guidance to be developed)	n/a

Aspect of soil degradation	**Selected soil descriptors**	**Ranges for soil health**	**Derogations (from both monitoring and achieving ranges by 2050(#))**
Loss of carbon	Soil Organic Carbon (SOC) (all uses except forests)	- For organic soils: respect EU targets set at national level under the NRL (wetlands); - For managed mineral soils: SOC/Clay ratio > 1/13; MS can apply a corrective factor where specific climatic conditions would justify it, taking into account the actual SOC content in permanent grasslands.	Heavily modified soils*
Soil erosion and eroded soils	erosion rate/risk	At soil district level: no eroded soils or unaddressed unsustainable erosion rate or risk (>2 tonnes/hectare/year)	Badlands and other natural areas, heavily modified soils
Excess nutrients: phosphorous	Extractable phosphorus in mg/kg (all uses)	<[30-50] ppm; MS to select the maximum threshold between the two values	Heavily modified soils
Salinisation	Electrical Conductivity dS/m (measurement only in dry and coastal areas)	<4 dS m−1;	Naturally saline soils must be excluded, heavily modified soils
Subsoil compaction	Bulk density in "subsoil" (B horizon) (all uses); MS can replace it with equivalent parameter and range	Sandy <1.8; Silty <1.65; Clayey <1.47; MS can replace this with equivalent parameter and range.	Heavily modified soils
Soil contamination	- heavy metals: As, Sb, Cd, Co, Cr (total), Cr (VI), Cu, Hg, Pb, Ni, Tl, V, Zn (all uses) - a selection organic pollutants defined by MS	MS to achieve reasonable assurance that no unacceptable risk for human health and the environment exist	Soils naturally high in heavy metals
Excess nutrients: nitrogen	Nitrogen in soil (all uses)	No ranges;	Heavily modified soils
Acidification	pH (all soils)	No ranges	Heavily modified soils
Soil biodiversity loss	Potential soil basal respiration Additionally, MS can select other soil biodiversity indicators such as: - Metabarcoding of bacteria, fungi and animals - Abundance and diversity of nematodes - Microbial biomass (all uses) - Abundance and diversity of earthworms (cropland)	No ranges	Heavily modified soils
Topsoil compaction	Bulk density in "topsoil" (A horizon) (all uses)	No ranges	Heavily modified soils
Separate assessment and monitoring			
Land take and soil sealing	Net land taken and imperviousness area	(targets set voluntarily by MS)	

Notes: *Heavily modified soils: soils where the provision of ecosystem services is almost completely hampered to such a degree that it is almost impossible to restore (such as sealed soils); (#) derogations require separate mapping and monitoring of derogated areas.

2.3.2 Assessment of impacts

Economic – Option 3

The additional ***administrative burden*** on Member States public authorities in terms of staff numbers, allocation, and time to establish soil districts and define soil health descriptor ranges would be more than in the baseline but less than Option 2 as the EC would have set some common criteria for soil district establishment and some common EU thresholds for soil descriptors – in theory this would somewhat decrease the administrative burden of individual Member States. In addition to this, it would be expected that if the EC is establishing definitions once, that the EC can do so more efficiently than 27 Member States can do so individually as under Option 2. However, this cost saving is dependent on the range of determinants and criteria for districts that are commonly defined by the EC – the smaller the set of descriptors for which ranges are set, the lower the administrative burden savings.

However, where Member States are required to follow the mandatory criteria to establish the districts, this may restrict the ability (and consequently the number) of Member States defining districts using a simpler, less costly process – e.g. based on administrative units. Hence under this assumption costs for some Member States may be higher than under Option 2.

The evidence available on which to estimate additional administrative burdens is sparse. However, illustrative estimates can be derived based on expert judgement. Under Option 3, there would still be an additional cost to defining districts – the EC would incur a small cost to define its mandatory criteria (0.5 FTE, or EUR 60,500) in addition to Member States investing effort to define the districts following the mandatory criteria. Assuming this is a more complex process (whereas under Option 2 many Member States may opt to define them as simple administrative units), the costs for Member States could be higher here, and could be assumed to be around 2 FTEs plus an external support project (total EUR 5.4m). Total additional upfront administrative burden to the EC could be around EUR 181,500 and around EUR 5.54m to Member States.

Table 2-6: Total administrative burden across SHSD options

Option number	EC – One-off costs	EC – Recurrent costs	MS – One-off costs	MS – Recurrent costs	Other – One-off costs	Other – Recurrent costs	TOTAL – one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 3	12,000	-	370,000	-	-	-	380,000	-

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

Environmental – Option 3

No difference in assessment to those assessed for Option 2.

Social – Option3

No difference in assessment to those assessed for Option 2

2.3.3 Distribution of effects

Under Option 3, the direct costs (administrative burdens) of the option will fall mainly on Member State Competent Authorities, with some additional small costs for the EC. Like policy option, there will still be a greater cost to Member States to determine soil health indicators and districts who are already lacking in soil information as, across the EU, the availability of soil information varies. Member States who have already begun to develop soil health descriptors will still face less additional costs than Member States who have not under this policy option.

2.3.4 Risks for implementation

Due to the input from the European Commission, and thus limited flexibility, Option 3 will lead to greater comparability and consistency with regards to soil health descriptor ranges/thresholds but also the determination of soil districts in comparison to Option 2. Nonetheless, Member States will have an obligation to restore all soils to good health by 2050 and there is still a risk of variation between Member States as some may work around the mandatory criteria and set threshold/ranges which have a lower impact than others, although this risk is lower under Option 3 in comparison to Option 2.

In comparison to Option 2, the high technical burden on the Member States of defining descriptor ranges and districts is somewhat lower due to the common criteria set by the EC. However, like Option 2, expertise would still be required to explore the remaining descriptors for which thresholds are not set at EU level and as such, there is a high risk of variation with regards to the remaining descriptors and thus a lack of consistency and comparability between Member States.

An additional risk for Option 3 is the extent at which the EC can define common criteria for descriptors and districts taking into consideration the variation in climatic condition, soil type and land use across all Member States. Although this is a risk for all Options this risk is higher in Option 3 in comparison to 2 (but this risk is highest in Option 4 and is explored in greater detail below).

2.3.5 Links /synergies

The links identified for Option 2 also apply here. Again, coherence varies between different options under different building blocks. Option 3 is more suited to Options 3 and 4 of building blocks MON, REST and SSM as the common criteria set out by the EU provides more consistency between Member States than Option 2, however the remaining variation may still create difficulties in *fully harmonising* monitoring, measures and actions under those building blocks. In addition to this, the remaining variation under Option 3 could limit the effectiveness of soil health certificates and passports due to the variation of ranges of the remaining descriptors. On the other hand, Option 3 has greater compatibility with Options 2 and 3 of other building blocks as the common criteria set by the EU acts as a target baseline for Member States to work towards.

2.3.6 Summary assessment against indicators

If the EU defines central, common criteria for the establishment of soil districts and provides some common ranges for soil descriptors, comparability and consistency between Member States is likely to be higher than under Option 2, whilst Member States still have flexibility to determine some descriptor ranges where the variation could be greatest depending on local characteristics. Furthermore, Option 3 has a lower administrative burden and is generally less costly than Option 2 on the Member States due to input from the European Commission and the lower technical burden placed upon the Member States. Coherence with other building blocks has therefore the potential to be higher under Option 3 than Option 2.

Table 2-7: Overview of impacts of option 3

Effectiveness	**Impact on soil health**	(+)	No direct impact, but is critical foundation for action to achieve good soil health, and will influence benefits achieved through SSM and REST
	Information, data and common governance on soil health and management	+++	Key benefit, in particular through appointment of Soil District Authorities. Given lowest implementation risks, benefits anticipated to be greatest under this option
	Transition to sustainable soil management and restoration	(+)	No direct impact, but is critical foundation for action to achieve good soil health
Efficiency	**Benefits**	+++	Improvement of data, information and governance key benefit
	Adjustment costs	0	No direct impact, but is critical foundation for action to achieve good soil health, and will influence costs of action under SSM and REST
	Administrative burden	-	Low administrative burden (< EUR 1m upfront or ongoing)
	Distribution of costs and benefits	-	Burden to define descriptors partly falls on Member States – some have already begun to take action whereas others have not.
Coherence		+	Option fairly coherent with options under other building blocks
Risks for implementation		-	Some risk of variance across Member States and technical complexity for EC remains, but both are lower than under Option 2 and 4 respectively

2.4 SHSD – Option 4: All descriptor ranges and soil districts defined at EU-level

2.4.1 Description of option and requirements for implementation

Option 4 contains several specific elements:

- EU to define thresholds or range of values to rate soil health status as being 'good', for all descriptors in the 'minimum list'. So far, possible ranges and thresholds identified for a set of descriptors as presented under Option 3 above.
- Soil districts to be established entirely by EU, based on a set of criteria on homogeneity bearing upon: maximum share of surface allocated to land uses other than the dominant land use in the soil district; maximum standard deviation in the values taken by the descriptors of the 'minimum list' between samples taken in the soil district (using the sampling procedures defined in the thematic area MON on monitoring).

2.4.2 Assessment of impacts

Economic – Option 4

The key difference in impacts between this and other options under the building block is the ***administrative burden.*** The evidence available on which to estimate additional administrative burdens is sparse. However, illustrative estimates can be derived based on expert judgement. Under Option 4, the EC would take on the task of defining districts –

costs are uncertain, but an illustrative estimate is that this may require an additional 'medium' cost, plus two external expert support projects to assist (implicating total a one-off burden of EUR 863,000 for the EC). Total upfront administrative burdens could be around EUR 984,000 for the EC, and EUR 405,000 for Member States.

Table 2-8: Total administrative burden across SHSD options

Option number	EC – One-off costs	EC – Recurrent costs	MS – One-off costs	MS – Recurrent costs	Other – One-off costs	Other – Recurrent costs	TOTAL – one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 4	66,000	-	27,000	-	-	-	93,000	-

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

Defining the soil health indicators and their ranges for all indicators at EU level will better ensure a "***level playing field*** and high level of environmental and health protection".[467]

Environmental
No difference in assessment to those assessed for Option 2.

Social
No difference in assessment to those assessed for Option 2.

2.4.3 Distribution of effects

As all additional burden is taken on by the European Commission in this Option, there is very little distributional risk.

2.4.4 Risks for implementation

Option 4 presents the lowest risk in terms of comparability and consistency in implementation across Member States, and ensuring consistency in ambition with respect to implementing SSM practices and restoration of soils to good health (REST). This can have indirect positive impacts, for example on biodiversity when you consider biological soil health descriptors in comparison to Options 2 and 3 where descriptors may not be as aligned.

However, defining soil districts and ranges for soil health descriptors at EU level is likely to be an incredibly complex, costly and time-consuming undertaking. This is demonstrated by the EEA's report[468] which explores the complexity, varying metrics, and associated limitations of defining common descriptors and thresholds to define soil health. One manifestation of this risk is where a set of generic descriptors are defined but which would be detrimental to soil health if they are not specific enough and consider the variation in climatic condition, soil type and land use of each Member State. This is reiterated by stakeholders who noted that stating that the design of the soil health descriptors and thresholds values need to take into account the diversity of environmental and socio-economic factors within the EU. Alternatively, there is a risk of significant

[467] EU Soil Strategy for 2030
[468] https://www.eea.europa.eu/publications/soil-monitoring-in-europe-indicators-and-thresholds/download

delay if the EC decide to conduct the research required to establish descriptor ranges at EU level taking into account the variation between Member States. Stakeholders emphasised this risk through the engagement activities – for example stakeholders stressed that what determines soil health is dependent on location, soil type, and other parameters, noting that some flexibility in the approach would be advantageous, in particular following a learning-by-doing or adaptive management approach as was the case under the Water Framework Directive.

The concern around a lack of flexibility under Option 4 was highlighted by stakeholders noted that Member States should have the flexibility to define soil health descriptor thresholds to responds to their specific circumstances and challenges. This was reiterated by another stakeholder who stated that Member States should set thresholds in accordance to their specific situations.

2.4.5 Links /synergies

The links identified for Option 2 also apply here. Defining soil health districts and descriptor ranges at EU level through Option 4, if done with location specificity in mind, may enhance consistency between Member States. If this is the case, this consistency and alignment, along with the Options chosen under the restoration building block, may have a greater, indirect impact on public health in comparison to Options 2 and 3. In addition to this, defining the range of soil health descriptors at EU level will determine the total surface of land in the EU which is classified as unhealthy. This, along with the Option chosen for the restoration building block, may indirectly affect the cost of soil restoration required (surface x cost per unit of surface) (REST). With this in mind, it could be argued that Option 4 is the most coherent with the other building blocks Option 4 as to implement Option 4 of building block monitoring and restoration you are most likely to need the most consistency across all Member States. In addition to this, Option 4 is also suitable alongside Option 2 of the monitoring and sustainable soil management building blocks as clear districts and ranges have been set which would then allow Member States to conduct their own monitoring/management.

2.4.6 Summary assessment against indicators

Whilst administrative costs are lowest under Option 4, it would be technically difficult, costly and time-consuming to establish a representative set of soil health descriptor ranges which are suitable for all Member States at EU level. For example, setting the threshold/ranges values for soil health descriptor acidification to the extent that it is specific and representative to each Member State would be challenging.

Table 2-9: Overview of impacts of option 4

Effectiveness	**Impact on soil health**	**(+)**	No direct impact, but is critical foundation for action to achieve good soil health, and will influence benefits achieved through SSM and REST
	Information, data and common governance on soil health and management	++	Key benefit, in particular through appointment of Soil District Authorities. But benefit curtailed relative to Option 3 given risks to implementation.
	Transition to sustainable soil management and restoration	**(+)**	No direct impact, but is critical foundation for action to achieve good soil health
Efficiency	**Benefits**	++	Improvement of data, information and governance key benefit
	Adjustment costs	**0**	No direct impact, but is critical foundation for action to achieve good soil health, and will influence costs of action under SSM and REST

	Administrative burden	-	Low administrative burden (< EUR 1m upfront or ongoing)
	Distribution of costs and benefits	**0**	Burden to define descriptors falls on EC.
Coherence		+	Option coherent with options under other building blocks
Risks for implementation		---	Technical complexity risks that EC define thresholds that are not optimal across all locations, too high-level, or process is prolonged

3 MONITORING (MON)

3.1 Overview

3.1.1 Building block outline

The aim of this building block is to improve monitoring of the status of soil across the EU, and subsequently the effectiveness of the measures taken towards achieving healthy soils.

3.1.2 Problem(s) that the building block tackles

The overarching problem (from the Intervention Logic) is that Soils in the EU are unhealthy and continue to degrade. The key problem specific to this building block is: ***sub problem A- Information*** from the Intervention logic**:** data and common governance on soil health and management is lacking or incomplete. This problem is driven by a range of drivers:

- No agreed method or parameters to assess soil health
- Lack of technological solutions, insufficient digitisation, gaps in research and innovation, etc.
- Complexity of the problem is sometimes difficult to grasp
- Lack of awareness of the importance of soil health
- Focus on short-term benefits without taking account of future costs and income related drivers.

3.1.3 Baseline

Despite standard methodologies for measuring soil descriptors, and LUCAS providing harmonised measurement of some soil parameters, the current state of soil monitoring across the EU is varied, incomplete and in general not harmonised across the EU and as a result, lacks consistency and comparability.

Table 3-1: Relevant policies to baseline for MON

Programme/ Policy	Relevant Component	Relevance to Monitoring
EU Soil Observatory (EUSO) & The Land Use/Cover area frame	The Land Use/Cover area frame survey (LUCAS) is an EU wide Land use/cover data collection survey which is carried out	LUCAS Soil currently provides harmonised measurement of some soil parameters across the EU. A selection of Member States use LUCAS soil

Programme/ Policy	Relevant Component	Relevance to Monitoring
survey (LUCAS soil)	every 3 years and is next planned for 2022 and includes field survey and a photointerpretation campaign.	data to complement their national monitoring system they have in place[469]. Information collected from LUCAS includes Current land cover and use; environmental information such as irrigation; landscape features; photos, for example crop photos; topsoil sample and grassland survey. Soil samples collected in previous surveys have provided measurements for organic carbon content, soil texture, soil structure and soil permeability. LUCAS data is used to monitor EU policies and programmes such as Common Agricultural Policy (CAP), Soil Thematic Strategy, Biodiversity Strategy for 2030, Farm to Fork Strategy, EU climate action and the European Green Deal, 2030 Agenda for Sustainable Development
EJP (European Joint Programme) Soil[470]	EJP SOIL is a 60-month European Joint Programme Cofund on Agricultural Soil Management to develop knowledge, tools and an integrated research community.	EJP Soils objectives include enhancing the understanding of soil management by targeting climate change adaptation and mitigation; food security and ecosystem services and; soil education across Europe. Eleven new soil projects are being introduced to address research gaps for example SOC sequestration, soil biodiversity. There are 8 projects specifically related to Soil data & Monitoring, mapping and modelling. (SCALE, SIREN (completed),, MINOTAUR, CLIMASOMA (completed), SensRes, ProbeField, SERENA, AGROECOseqC). The SIREN project by EJP involved 20 MS countries and began in February 2021, the project involved a stocktake amongst EJP Member States use of soil data in ecosystem services assessment (if they do this and how) and, if they don't, the project collated the knowledge gaps and challenges facing policy implementation. The SIREN project has created a recommendation on a tiered soil health monitoring system and found harmonisation of soil health indicators were favoured by most but there was concern over the methodology used to assess the indicators as methodology traditionally varies between Member States and so there was resistance towards standardisation of methodology. Detailed mapping of soil health indicators by Member State can be found in section 6. EJP Soil is beginning a course of action to validate a select number of transfer functions for soil parameter measurements, this is being done by taking double samples and measuring them when with national or LUCAS soil methods.
Industrial Emission Directive (IED)	IED aims to prevent pollution through the application of Best Available Techniques (BAT). A baseline report is used to monitor and report on soil contamination (pollution occurrences on soil) and be used as a reference point to monitor any changes in the level of soil contamination. Where 'significant' pollution has been caused, the operation must take the necessary steps to return the soil to baseline level or, alternatively buy additional permits.	Whilst the scope of the IED is limited, it does include environmental protection obligations such as reporting on soil contamination through the formulation of a report and monitoring the steps to return the soil to baseline level.
Common Agricultural Policy CAP	All Good Agricultural and Environmental Conditions (GAECs) Member States shall define, at national	All GAECs are relevant to soil management to varying extent (direct / indicrect) and its capacity to provide ecosystem services and set specific

[469] in 2018 LUCAS obtained results from: Belgium, Bulgaria, Czechia, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom

[470] The 24 participating countries include France, The Nederlands, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey & United Kingdom

Programme/ Policy	Relevant Component	Relevance to Monitoring
	level the minimum requirements for GAEC. CAP indicators are developed taking into account specific characteristics, including soil and climatic condition, existing farming systems, land use, crop rotation, farming practices, and farm structures	requirements which are to be met/monitored
Environmental Crime Directive (ECD)	(ECD aims to enhance compliance with the EU environment protection legislation by supplementing administrative sanctions regime with criminal law penalties. The proposal has not yet entered into law). Current changes include an obligation for Member States to collect reliable statistical data and to support and assist people who report environmental offenses and cooperate with law enforcement.	The draft directive requires Member States to "reflect on 'aggravating factors' such as the extent to which the offence caused destruction or irreversible or long-lasting damage to an ecosystem and two 'mitigating circumstances' such as the extent to which the offender restores nature to its previous condition."
Nitrates Directive	Protecting surface waters and groundwater against pollution by nitrates from agricultural sources. One main implementation point of the Nitrates Directive is national monitoring and reporting. Member States develop and implement monitoring programmes to assess the effectiveness of action programmes Monitoring repeated every 4 years, unless previous concentrations were low and a rise in levels is not expected (8 years) Commission can provide monitoring guidelines Monitoring result summary provided to the Commission every 4 years.	Monitoring nitrate content of waters and selected points and reporting impact of nitrate action plans on agricultural practices has a direct impact on soil health
Water Framework Directive	Framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater through management plans and programmes of measures Member States establish monitoring programmes and sites Member States are to provide monitoring network maps and select monitoring parameters in addition to a core set of parameters Member States to submit summary reports of their monitoring programmes for the first river basin management plan	Monitoring, reporting and evaluation which addresses agricultural activities which can also impact soil health
EU Soil strategy	Restoring degraded soils is a common standard. Soil data and monitoring- actions from the European Commission include: • Considering provisions on monitoring and reporting on the condition of soil, developing national and EU schemes already in existence and provide a legal basis for LUCAS • EU-wide harmonised monitoring of the evolution in soil organic carbon content and carbon stocks • Integration of a pollution module into LUCAS In implementing the EUSO: • Identify soil monitoring gaps (with the contribution of the European join programme on agricultural soil management) • Alongside reliable soil indicators, develop a soil dashboard which includes trends and foresight • Develop an EU inventory of soil biota to monitor soil biodiversity	EU wide Monitoring of soil condition, restoration progression and evolution of SOC content

Programme/ Policy	Relevant Component	Relevance to Monitoring
National Emission Ceilings (NEC) directive	The NEC directive requires Member States to report air pollutant emission inventories to track progression and ensure compliance and establish National Air Pollution Control Programmes	Measures include monitoring diffuse contamination of agricultural soils and monitoring ammonia emissions with the aim to promote organic fertiliser
European Environment Agency (EEA) reporting/Environmental monitoring	Indicators- EEA indicators support policy making by displaying the status of each indicator. The EEA soil specific indicator is "Land and Soil", with code Indicator-LSI003. State of the Environment Report (SOER 2020)	The EEA indictor 'Land and Soil' sub indicators include: • Land take • Soil moisture • imperviousness and imperviousness change • organic soil carbon • progress in the management of contaminated sites The 'progress in the management of contaminated sites' indicator is included in the SOER 2020. Indicator Parameters aim to provide an insight into the current level of management of contaminated sites through voluntary reporting on contaminated sites by European Countries. The SOER 2020 also stated that future attention on monitoring the effects of emerging contaminants, for example microplastics, is required and looking forward to 2030, to guide sustainable soil management and enhance the early warning of exceedance of critical, thresholds, representative and harmonised soil monitoring is required across Europe.
Sewage Sludge Directive (SSD)	The SSD aims to prevent heavy metals in sewage and sludge exceeding limits to protect the environment, humans, animals and plants (concentration limits of heavy metals cadmium; copper; nickel; lead; zinc; mercury and chromium are set by the directive) and increase the amount of sewage sludge used in agriculture.	Monitoring and regular reporting by Member States to the European Commission on the SSD every three years and the assessment of soil contamination for heavy metals prior to spreading sewage sludge
The Infrastructure for Spatial information in the European Community (INSPIRE) Directive	INSPIRE Directive aims to create EU spatial data infrastructure for policy. INSPIRE directive datasets are listed under 34 themes (one of which is soil) and requires Member States to adopt implementing rules (IR) to ensure data is compatible.	Member States to establish soil spatial information and manage compatible spatial datasets
Renewable Energy Directive (RED) II	Article 10 on Agricultural feedstock for the production of biofuels, bioliquids and biomass fuels	Agricultural feedstock should be produced using practices which are in line with the protection of soil organic carbon and soil quality. Therefore, soil organic carbon and soil quality are included in monitoring systems
Soil Mission (Horizon Europe)	A Soil Deal for Europe	In 2021, EUR 12 million was dedicated to soil monitoring and research on soil health indicators

A number of Member States have existing soil monitoring schemes in place, most of which were developed in the 1990s (countries include Austria, Southern Belgium, Bulgaria, Switzerland, Germany, France, Hungary, Iceland, Italy, Netherlands, Portugal, Slovenia and Sweden). These deploy a variety of monitoring sites, sampling methods (for example random sampling and judgemental sampling) and sampling areas (which range from 5 m^2 to 1ha), thus showing a current lack of consistency and comparability across the EU. Further detail on the extent of existing monitoring programmes at national level, and their coverage of different descriptors can be seen in section 6.

The Land Use/Cover area frame survey (LUCAS) is an EU wide Land use/cover data collection survey, the latest survey took place between March and September 2022 and included a field survey and photointerpretation campaign. LUCAS Soil currently provides harmonised measurement of some soil parameters across the EU and could act as a reference for comparability of national measurements. A selection of Member States already uses LUCAS soil data to complement the national monitoring system they have in place.

Despite the above efforts to gather and report data and information on soils, in summary, soil monitoring remains varied across the EU with regards to territorial level (national/regional/local). Whilst many Member States have soil data, the data is often not yet shared publicly in accordance with the mechanism of the INSPIRE Directive and is therefore not yet sufficient to ensure coherent monitoring across the EU. Stakeholders emphasised the key issue presently is the lack of harmonisation of approaches to collect and compare data. The discrepancies between Member States, and the fact that some Member States have set monitoring processes in place whilst others do not, was apparent in the evidence provide by stakeholders, who noted for example:

- Austria monitors land take and soil sealing and in some parts soil contamination also. Austria federal states began soil monitoring in 1990 and soil characteristics include pH, organic matter, heavy metals and metalloids and soil nutrient availability (P, K).
- Both Flanders and Czechia highlighted the lack of soil organic matter monitoring, but Flanders actively monitors soil sealing, remediation and erosion risk and Czechia has systems in place to monitor soil erosion, a system for evidence of contaminated locations and agrochemical testing of soil.
- Germany does monitor soil organic carbon stocks and changes, although limited to forest and agricultural soils.
- Denmark has an extensive sampling programme measuring soil organic carbon contents.
- Estonia have a specific National Soil Monitoring System in place as part of the National Environmental Monitoring System which is currently covering agricultural soils in 30 monitoring sites
- Croatia and Malta do not have any official and consistent monitoring of soil and land degradation processes in place.

In the 2017 'Gap assessment in current soil monitoring networks across Europe for measuring soil functions', where Van Leeuwen et al. assessed soil attributes which can be used as indicators of soil functions (primary production, water purification and regulation, carbon sequestration and climate regulation, soil biodiversity and habitat provisioning and recycling of nutrients) and compared these to national, regional and EU wide soil monitoring networks. The comparison highlighted not only a variation in indicator methodology across countries but also an under representation of biological and physical soil attributes such as microbial biomass (biological) and bulk density (physical) In addition to this, the variation in indicator methodology across countries was apparent.[471] This was reiterated by stakeholders who highlighted that for some territories, there is no common soil sampling and laboratory methodology across the various laboratories undertaking analysis. In addition, stakeholders explained that if a foreign laboratory is used for analysis, sample collection and transportation conditions may be in line with the practices of the foreign laboratory as opposed to their own.

[471] van Leeuwen, J.P., Saby, N.P.A., Jones, A., Louwagie, G., Micheli, E., Rutgers, M., Schulte, R.P.O., Spiegel, H., Toth, G. and Creamer, R.E., 2017. Gap assessment in current soil monitoring networks across Europe for measuring soil functions. Environmental Research Letters, 12(12), p.124007.

3.2 MON – Option 2: Sampling and data collection left to Member States

3.2.1 Description of option and requirements for implementation

All options under the MON building block contain the following elements:

- Obligation for Member States to monitor in-situ and report on current status of soil health at least every 5 years, for all ‘soil districts’ and for all soil descriptors of the ‘minimum list’ (defined in SHSD). Provisional soil health monitoring parameter(s) and expected actions following monitoring are displayed in the table below.
- Remote monitoring at EU level of aspects linked with soil health, such as the following parameters: imperviousness, land cover, soil moisture deficit, and to report on it at least every 3 years with a maximum delay of 2 years since the measurement.
- EU to establish a legal basis for LUCAS as the EU oversight system.
- Provision of mandate on the access to land, use of data and privacy issues for the LUCAS soil survey. This includes provision of the legal basis to ensure access to land is granted by landowners.
- Assumption that remote sensing data is processed at EU level and made available to Member States.

Option 2 also includes some elements specific to this option:

- Member States to define the method for measuring the soil parameters, based on an indicative set of standards proposed by the EU; if not using the indicated methods Member States should use the available transfer functions to translate the measured values into values consistent with LUCAS soil methods
- Member States to define as well other elements of the methodology not described in the standards concerning (including as relevant: time, seasonality, depth) for all soil health descriptors in the ‘minimum list’.

Work is already underway to develop transfer functions from Member State level monitoring programmes to LUCAS and planned for delivery early 2024. Although this currently only focuses on chemical and physical parameters.

In response to the OPC, there was a strong agreement across all stakeholder types that there should be legal obligations for Member States to monitor soil health in their national territory and report on it. 89% of all respondents ‘totally agreed’ this obligation should be put in place, with a further 8% ‘somewhat agreeing’. ‘Totally agree’ was also the most common response across all stakeholder types, with Business Associations being the only exception, where ‘somewhat agree’ was the most frequent response followed by ‘totally agree’).

Stakeholders noted that there are different steps to data collection: sampling, lab work, interpretation of data, organisation of data in a database and reporting. It was noted that the level of standardisation required would differ across different steps and hence it is important to consider where standardisation is most needed. With respect to laboratory analysis, stakeholders highlighted that ISO standards already exist and are available for all labs to follow. Alongside monitoring, stakeholders also highlighted the importance in (and benefit of obligating) reporting across Member States, in particular achieving standardisation across Member States.

3.2.2 Assessment of impacts

Economic

With regards to soil sampling, site preparation and sample collection incur time, capacity and economic impacts[448]. Due to the differences in soil health descriptors, a variety of sampling techniques will be required as presented in the table below.

In addition to this, transport of soil samples to the laboratory will endure an economic impact, in particular where transportation of samples needs to meet specific conditions (e.g. if samples are required to maintain soil moisture levels)[448]. Examples of such conditions were provided by stakeholders. For example, one noted that its Soil Department requires their samples for mineral nitrogen (nitrate and ammonium) must be sampled, stored and transported within 24 hours, with a temperature <5°C (biological parameters must be stored under cool conditions) and any DNA/RNA analysis must be frozen on field and requires specific sampling equipment. However, soil parameters on nutrient status (pH, P, K, Mg, Ca, SOC etc) do not require a specific storage temperature between sampling and testing but cannot have lost all moisture before being testing at The Soil Department facilities. Other stakeholders also reiterated that biological parameters must be stored under cool conditions (i.e. < 4°C) as fresh biological soil property is required for analysis. Stakeholders provided useful data and inputs regarding the costs of sampling and its different components – e.g. one noted a material cost of soil sampling of EUR 150 which includes transport costs, equipment, consumables and energy.

Table 3-2: Soil tests for the soil health descriptors

Soil health descriptor	Soil test	Soil sample
Acidification	pH of soil solution in H2O and CaCl2 extract (ISO 10390:2005), lab based	bulk sample
Topsoil compaction	Taking soil core (ISO 11272), measuring dry weight, lab based	core sample for bulk density
Subsoil compaction	Taking soil core ISO 11272, measuring dry weight, lab based	core sample for bulk density
Loss of soil capacity for water retention	Determination from other parameters measured (ISO 11274:2019)	n/a
Loss of carbon	Determination of organic and total carbon after dry combustion (ISO 10694:1995), lab based	bulk sample
Soil erosion and eroded soils	Model soil erosion with RUSLE	n/a
Salinisation	pH of soil solution (GLOSOLAN-SOP-08) directly or specific electric conductivity indirectly (ISO 11265:1994), lab based	bulk sample
excess nutrients: phosphorous	Spectropmetric determination of phosphorus soluble in sodium hydrogen carbonate solution (P-Olsen) (ISO 11263:1994) , lab based	bulk sample
excess nutrients: nitrogen	SMN testing or modified Kjeldahl method (ISO 11261:1995) common, lab based (total N also used)	core sample
Soil biodiversity loss	Metabarcoding: DNA test; Nematodes: baerman funnel technique and ID common, too time consuming, will need to move to DNA based techniques, under development; Microbial biomass: several methods, lab based;	bulk sample for metabarcoding and microbial biomass, refrigeration during transport required; separate sample for nematodes; earthworm test and soil basal respiration undertaken

Soil health descriptor	Soil test	Soil sample
	Earthworms: abundance can be done on the field, diversity possibly lab based	in field
Soil contamination	Several methods for pseudo-total content of heavy metals in soils based on: - trace elements in *aqua regia, followed by boiling; under reflux and analysed by spectrometric techniques* (ISO 11466:1995) *or after* microwave digestion (EN 16174) - potential environmental available content using dilute nitric acid (ISO 1756:2016); - cation exchange capacity (ISO 23470:2018), standardized methods available, lab based	bulk sample

A further economic impact is the soil sample analysis and laboratory costs. Indicative costs of soil analysis (particle size, pH, SOC, carbonates, total N & K, available P, electrical conductivity, cation exchange capacity, selected heavy metals, water content for bulk density) are estimated at around EUR 30 per sample,[472] and DNA testing are estimated at EUR 150 – 1,000[473] (noting that costs are reducing over time). Stakeholders again provided useful data and information to corroborate the costs of soil sample analysis. One stakeholder provided quantitative information on the cost breakdown of their national soil monitoring regarding soil contamination:

- soil sampling 1,430 €/ site (sampling, obtaining permission from landowners for soil sampling, field sampling records, final report, standard printout. This includes analytical determination of soil contamination parameters:
  - 86 €/soil sample (sample preparation)
  - 177 €/soil sample (total fluorides, Hg, Cd, Pb, Zn, Mo, Cu, Co, As, Ni, Cr)
  - 600 €/soil sample (PAH, PCB, volatile phenols, benzene, ethylbenzene, toluene, xylene, mineral oils, DDT/DDD/DDE, drins, HCH compounds, atrazine, simazine)
- Analytical determination of pedological parameters: 140 €/soil sample (dry matter, texture, organic matter, organic carbon content, total nitrogen, pH in CaCl2, plant available phosphorus (P2O5), plant available potassium (K2O); exchangeable Ca, Mg, K, Na; exchangeable acidity, sum of bases, cation exchange capacity, degree of saturation with bases, electrical conductivity, bulk density).

Another example of cost from 2008 estimated €4m for the "1) costs and precision of varied sampling intensities at plot level, 2) sample size and 3) costs needed to detect a change in forest soil carbon stocks at the national scale".[474]

Another stakeholder highlighted that the cost of soil health testing is decreasing rapidly. Additionally, through economies of scale and digitalisation, costs are decreasing further and are expected to decrease even faster over the next years. Feedback from experts noted that the annual budget for the LUCAS soil survey is around EUR 3.5m for a survey covering the following indicators to varying degrees at 22,137 sampling points (LUCAS

[472] Working paper for the Soil Health Law: Soil Health Monitoring and LUCAS
[473] Response to targeted stakeholder consultation
[474] http://urn.fi/URN:NBN:fi-fe2016083123310

2018) across the EU[475]: Basic soil properties, Metals, Bulk density, Organic soils and Soil erosion (implying a cost of Using the above information, the costs per sampling site can be estimated to be around EUR 158 per site).

A stakeholder highlighted the following costs for gathering data for Soil Health certificates which have been adopted in estimations of additional monitoring costs.

Table 3-3: Estimates of costs of gathering data for Soil Health Certificates

	Cost (EUR)
Labour: preparations, site visit, sampling, sample management and administration	100 (assumed to be equivalent to 1 days labour)
Materials: transport costs, equipment, consumables, energy	150
Physical analysis set: 150 – 300 euro Examples: moisture, texture, density, hydrology, aggregate stability	150 – 300
Biological analysis set	150 – 1,000

Many Member States are already monitoring and collecting data against the soil health descriptors, although are doing so in an inconsistent way – i.e. monitoring different groups of indicators, over different spatial scales, with different frequencies, etc. Where Member States are already undertaking monitoring but subsequently need to conform to a common system under the option, there will be a transition cost for these Member States. As noted above, work is already underway to calculate transfer co-efficient for several descriptors between existing monitoring and LUCAS, which should reduce the transaction cost, however both systems will need to coexist.

Member States may incur additional monitoring costs:

- To ensure a complete coverage of the minimum list of descriptors at existing sites
- To ensure the required 5-year frequency of monitoring at existing sites
- To introduce new sampling sites to achieve the required coverage to assess soil health descriptors to a sufficient level of robustness.

Recording and reporting the soil status will add an additional ***administrative burden***[476] for Member States and the cost of monitoring is additional to that already incurred by Member States for monitoring for the duration necessary to calibrate the transfer functions but would somewhat be in substitution to these existing costs once transfer functions are stabilised. Furthermore, if soil samples are to be re-analyzed (in line with continuing research and development of soil health indicators in building block SHSD), in the event of the development of new sampling techniques, there will be an economic impact on the storage of soil and data samples.[477]

With regards to remote sensing data, which will not be used to capture data to directly assess any of the soil health indicators, it identifies the areas to monitor I.e. non-sealed land and as such, reduces the cost of some monitoring parameters.

[475] JRC, 2018. LUCAS 2018 Soil Module. Available at: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/dataset/75-LUCAS-SOIL-2018/JRC_Report_2018%20LUCAS_Soil_Final-v2.pdf
[476] RECARE_D9.1_Up_to_date_review_of_EU_policies
[477] Good Practice Guidance. SDG Indicator 15.3.1, Proportion of Land That Is Degraded Over Total Land Area. Version 2.0.

Monitoring the health condition of soils across the EU could lead to – ***Technological development/ – Innovation (productivity and resource efficiency); research (academic and industrial)***, for example the use of "artificial intelligence solutions from sensing systems" and "field-based measuring systems (e.g., hand-held spectrometers, portable DNA extraction, on-site chemical analysis".[467] This development, research and innovation would have a direct and positive economic impact. Furthermore, there could also be a direct and positive impact on the ***Conduct of business and position of SMEs*** such as laboratories within each Member State due to the increase in their services to carry out the analysis of the soil samples.

Economic impacts – Option 2

Estimating additional administrative burden of Option 2 is challenging, in particular as it is uncertain how many additional sampling points will be identified by Member States and/or what additional testing (e.g. for biodiversity, or density) will be required at existing sampling sites. Member States may increase the number of samples, frequency of measurement and parameters measured. However, it is possible that some Member States may limit their additional ***administrative burden*** by developing a system to focus monitoring on priority areas and/or which presents limited additional improvement over and above their existing monitoring programmes (but this would also impact on the comprehensiveness and comparability of the data across Member States).

Through the implementation of Option 2, it will be up to the Member States to determine the soil testing regime at each sampling site. An illustrative estimate of additional administrative burden of additional sampling at new and existing sites places the burden at around EUR 47.2m for Member States on an ongoing basis. This is based on all Member States deploying a geostatistically-determined sampling network by the JRC (216,000 soil samples) that achieves a soil sample grid that would be able to assess soil health with an error of 5% (so Member States with fewer need to add new sites), and deploying a testing regime that will cover all soil health indicators. Under Option 2, it is assumed that Member States will not develop LUCAS transfer functions to ensure that their collected soil data is comparable with the LUCAS soil 2022 dataset, hence Member States would need to implement additional new testing sites as LUCAS data could not be used directly in the assessment of soil health against the descriptors. There would also be additional burden for Member States around defining their adopted soil health measurement methods at 2 FTE or EUR 2.7m. For the EC, there be high administrative burden (5 FTE or EUR 605,000) across all the options to develop an indicative set of measurement standards. Further detail surrounding the additional monitoring cost calculations can be found in section 6.

Table 3-4: Total administrative burden across MON options

Option number	EC – One-off costs	EC – Recurrent costs	MS – One-off costs	MS – Recurrent costs	Other – One-off costs	Other – Recurrent costs	TOTAL – one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 2	54,000	28,000	180,000	49,000,000	-	-	240,000	49,000,000

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

Environmental –Option 2

Monitoring soil alone will not have a direct impact on the environment. That said, the frequency and quality of soil monitoring will have a significant indirect impact on the soil and surrounding environment, as it will directly feed into the determination of soil management plans and restoration activities actioned under other building blocks (SSM and REST – see section on linkages below). Hence the quality, comparability and consistency of the data collected will have a direct bearing on the effectiveness and consistency of the subsequent plans made. As such, soil monitoring has an indirect, significant impact on a wide range of ecosystems and the services they provide. Examples of these ecosystems and services include carbon sequestration, air pollution regulation, water quality and availability, biodiversity and natural hazards such as flooding.

Social –Option 2

Soil monitoring and the data collected from soil monitoring can have a positive and direct impact on the ***provision and use of information*** for further research and development into actions/measures which can improve/maintain the status of soils across the EU. Increasing the amount of publicly available soil monitoring data will help to increase the public awareness of soils and the challenges they face. Sharing data and information on soil health can be used to make more informed decisions about sustainable soil management practices.

Soil monitoring does not have a direct impact on ecosystem services such as ***food safety, food security*** and nutrition (one of a range of ecosystem services that soil supports, other examples are mentioned in the '*Environmental*' section above). However, the data and information collected will determine and monitor the frequency of action/measures required to ensure soil across the EU can fulfil various societal needs such as food production and food security as well as measuring degradation and defining a loss of ecosystem service which will have an impact on social well-being.

Through the investment in additional monitoring networks and the processing and reporting of data, this option will also have a positive impact on ***employment***. Based on the additional administrative burden to implement a reliable monitoring network under Option 2, it is estimated that this could lead to a direct employment effect of an additional 410 FTEs on an ongoing basis. There will also be additional indirect and induced employment effects as the impacts ripple through the economy. Although more uncertain than the estimate of direct effects, an estimate of the total employment effects is around 560 additional FTE jobs on an ongoing basis. Further detail of the approach and results to estimating employment effects is presented in section 10.

3.2.3 Distribution of effects

As mentioned in the economic impacts, regardless of whether Member States or the European Commission determine the soil districts, some Member States may have more (or larger) soil districts than others (determined by building block SHSD). More specifically, some Member States have a greater level of heterogeneity, and as such may have a greater number of districts, and this may not necessarily vary in line with size (or GDP) of Member State: for example, Germany is regarded as relatively homogenous with large arable areas, hence could have many fewer districts in relative terms to say Slovenia. This will mean that some Member States will be required to do more monitoring than others which will also affect the burden of monitoring costs across the Member State.

For Member States who already have soil monitoring frameworks in place the economic burden is lower than Member States who will be implementing a monitoring framework for the first time.

Regardless of whether it is the Member States or the European Commission who determine the soil districts, the total number of monitoring points will be proportional to the size of each Member State, soil homogeneity and their use of soil (which is associated with population density). This variability between Member States will mean that some Member States will require more monitoring points than others which will impact the burden of monitoring costs across the Member States.

Otherwise, there is no significant driver of a differential impact between different stakeholders and stakeholder types – e.g. between rural and urban areas.

3.2.4 Risks for implementation

A risk on result validity was highlighted by stakeholders who noted that it would be important to consider and capture whether observed changes in soil health were in response to true changes in health, or simply a response to changes in, for example, laboratory (which may include for example a change in transportation time).

A further risk concerns land accessibility to collect soil samples. That said, stakeholders noted that their general perception was that the collection of soil samples occurs with minimal access problems. Furthermore, providing a legal basis for LUCAS will lower this risk further.

A risk highlighted by stakeholders is that remote sensing techniques to date are of insufficient quality to build reliable trend data and capture multiple soil health descriptors. Namely the error bounds are too wide to build trends with a sufficient level of confidence. In particular, some stakeholders highlighted that there is no current COPERNICUS service that can identify soil erosion at the scale required by the soil health descriptors – hence remote sensing is not mature enough to capture soil losses. It was noted that this captures little information beyond establishing soil cover and as such, will likely not be able to be used to directly address any of the soil health descriptors. Hence in-situ monitoring is critical as this delivers greater accuracy.

Option 2

Under Option 2, greater flexibility is given to Member States to define monitoring procedures. As such there is a risk that Member States who already have a monitoring frameworks in place simply continue with (or do not sufficiently expand) these systems. Indeed stakeholders noted that there is a preference amongst Member States to retain their national systems to maintain continuity in their data sets. Member States have the opportunity under Option 2 to limit their additional administrative burden by developing a system to focus monitoring on priority areas. Hence under Option 2 there is a higher risk that comprehensiveness and comparability of the data across Member States is not substantially improved. Stakeholders emphasised the key issue presently is the lack of harmonisation of approaches to collect and compare data. Stakeholders also highlighted a clear need for standardisation of monitoring in some form wherever possible, including where in the chain of monitoring standardisation could be applied (sampling/lab work/interpretation of data/organizing data into databases). Stakeholders also noted that the ‘sufficiency’ of the information provided through the monitoring programme is somewhat subjective – further underlining that where greater flexibility is provided to Member States, there is a higher risk of variation in methods, strategies and precision between Member States.

There is also a risk surrounding laboratory capacity and location and whether a larger level of sampling could be adequately processed in a timely manner. Under Option 2, the Member States have greater control to design monitoring systems to best mitigate this (and also may not increase the number of sampling points as much as under Options 3 and 4) and hence this risk is lowest for Option 2.

Stakeholders also stressed the need to ensure continuity with trends measured previously, underlining the importance of the development of a set of robust and widely adopted transfer factors. Other stakeholders highlighted a benefit in an indicative set of methodologies provided by the EU which either have to be followed by Member States, or where not a set of transfer functions to LUCAS must be used – they noted this could ensure compatibility between LUCAS and Member State approaches- this has the advantage that Member States with no active monitoring programme can adopt LUCAS approaches or benefit from complementary data from every LUCAS iteration, and LUCAS can also benefit from the data collected by national monitoring programmes. However, under Option 2 where transfer factors are not comprehensively developed, and instead use what is available in science this can limit the comparability between LUCAS and Member States approaches as there may not be available transfer functions for some descriptors and as such Member States cannot map their monitoring against LUCAS.

3.2.5 Links /synergies

Once a clear set of soil health descriptors is defined through the soil health and districts building block, whether that be at EU or Member State level, a monitoring programme can then be designed and implemented in terms of scale and sampling methodology. SHSD will set the requirements for the monitoring building block, and hence also somewhat drive the costs of monitoring.

Monitoring soil health is necessary to determine the current status of the soils and as a result of this, which actions need to be taken to restore ‘unhealthy’ soils to ‘healthy’ which may require investigation and additional testing or maintain the ‘healthy’ soil status (sustainable soil management practices). In addition to this, periodically monitoring changes to soil health is essential to inform whether actions taken are effective (monitor deterioration and improvement). It must be kept in mind that if all monitoring was left to the Member States under Option 2, there is a risk that they may not collect sufficient information to monitor against the sustainable soil management practices or Restoration programs, especially if the sustainable soil management and restoration building blocks are under policy option 4 and/or Member States may define monitoring procedures in such a way as to limit the restoration activities they need to undertake. The monitoring building block, like the Soil health and Soil district building block, is highly influential and a key driver of the size of economic, environmental, and social impacts of other building blocks, in particular the restoration building block

Monitoring is required alongside the collection of standardised, accessible data at sufficient level of granularity to facilitate soil health certificates (CERT2). Otherwise, the costs of soil health certificates increase. Similarly monitoring soil health and status is necessary to know if the nutrient target (NUT) has been achieved.

Soil monitoring under Option 2 lends room to the lowest consistency and comparability between Member States, which means it is least compatible some options under other building blocks. For example, with Options 4 for SSM and REST as some Member States may not collect the information required to monitor against the prescriptive set of management practices/ restoration actions.

3.2.6 Opinions of stakeholders

Opinions received on the monitoring obligation are summarised in the table below, for each Member State and other stakeholder categories. Information was extracted from written feedback received from Member States and other stakeholders. Member States generally support an obligation for long-term monitoring, in many cases with minimum requirements harmonised on EU level. Nevertheless, it was also flagged that the harmonised approach should reflect the fact that some Member States already have monitoring approaches in place, to avoid duplication. The added value of LUCAS has been recognised as well, though with some reservations regarding its overall applicability.

Table 3-5 Overview of stakeholders' opinions

	Obligation to monitor soil health	Obligation to monitor the effectiveness of the measures	Legal basis for LUCAS and remote sensing as EU oversight system
Austria	• Long-term monitoring is necessary because soil changes can be detected over long period of time only MS should adjust frequency of measurements (intervals of max. 4 years).	No input provided.	LUCAS should maintain its current role
Belgium	• Long-term monitoring is necessary because soil changes can be detected over long period of time only MS should adjust frequency of measurements (intervals of max. 4 years). Nevertheless, parameters should allow for a cost-proportionate action at the correct level of governance.	No input provided.	LUCAS soil could fill in gaps when no or less detailed data are available at MS/regional level.
Bulgaria	No input provided.		
Croatia	No input provided.		
Cyprus	No input provided.		
Czechia	No input provided.		
Denmark	No input provided.		
Estonia	No input provided.		
Finland	SHL can include an obligation for MS to identify national monitoring requirements. Only minimum requirement for MON should be defined at EU level, with parameters	No input provided.	• Doubts regarding LUCAS' results on peat and forest soil. Issue of data protection, which ca hinder data availability and cause

	relevant to the entire EU. Existing MON obligations should be taken into consideration (e.g. NEC, LULUCF, GHG, etc.).		admin burden
France	The following parameters should be monitored: erosion, porosity, salinisation, compaction, pollutants, and the available water capacity.	No input provided.	• Minimum set of common sampling sites in the MS, the number defined by the SHL.
Germany	Long-term monitoring is necessary because soil changes can be detected over long period of time only MS should adjust frequency of measurements (intervals of max. 4 years). Nevertheless, it should be ensured that MS monitoring obligation do not contradict existing national measures.	No input provided.	• LUCAS is a valuable component and requires better integration within MS monitoring programmes as it is considered as a valuable component to MS efforts.
Greece	No input provided.		
Hungary	No input provided.		
Ireland	MS should assess and monitor regularly the set of parameters that will constitute the definition of Soil Health for the different land uses. Monitoring frequency of 4 years or less. Existing monitoring systems for other EU legislation may not be based on the criteria relevant for monitoring soils.	No input provided.	LUCAS should maintain its current role as it is unlikely to provide the needed level of detail related to soil health.
Italy	No input provided.		
Latvia	No input provided.		
Lithuania	No input provided.		
Luxembourg	The frequency of data collections, monitoring and reporting in the framework of the SHL should be harmonized with the other main requirements of the CAP, the NEC Directive, the Nitrate Directive, the LULUCF, etc.	No input provided.	LUCAS should primarily be used for collecting and densification of basic soil parameters. It is not suitable to provide enough information for practical implementation of soil management practices. It also provides a common basis to assess EU trends and a common reference base.
Malta	No input provided.		
Netherlands	Regional differentiation is not a practical approach for EU level monitoring. Instead, a hybrid approach such as performed in LANDMARK/EcoFinders can be part of the solution. So, the most important focus is on the dominat + general types of land use, soil type and climatic zone. Invite (suites of) member states to focus on unique strata in land use, soil type, climate zone. E.g. peat soils are for sure interesting, but it is not very useful to monitor with peat soil specific indicators in the south of Europe.	No input provided.	LUCAS should maintain its current role, with an increased number of sample points for biodiversity.
Norway	A number of common requirements	No input provided.	No input provided.

	for monitoring can be set (e.g. risk-based).		
Poland	The focus should be on developing a common MON methodology regarding the method of determining test points, determining the depth of sampling for testing, research methodologies for individual parameters. The number of obligatory tested parameters should be decided later.	No input provided.	LUCAS monitoring shall be a reference programme for national monitoring programs through providing harmonisation guidelines and reference data that would help to translate national data into the European database (including transfer functions).
Portugal	There should be a harmonised EU approach, with MS carrying out individual monitoring.	No input provided.	LUCAS should be relied upon as it represents the only regular and harmonised collection of soil samples in the entire EU territory.
Romania	No input provided.		
Slovakia	No input provided.		
Slovenia	Frequency of monitoring can differ per parameter. This needs to be defined, including status and trend of what soil to monitor (e.g. soil health, ecosystem services, etc.).	No input provided.	Global soil parameters haves used LUCAS data to prepare soil related maps (including for some MS), but consent of each country was needed.
Spain	No input provided.		
Sweden	No input provided.		
Other public authorities	Monitoring is time and cost-intensive due to bureaucratic hurdles (Local authority, Gemeente Rotterdam). It is up to Member States to decide shall decide on the monitoring indicators for healthy soils (UBA Germany).	No input provided.	No input provided.
Farmers	There is not a high interest in EU minimum requirements as many French regions already have monitoring strategies in place ((Comite du vin Champagne).	No input provided.	No input provided.
Foresters	No input provided.		
Land owners / land managers	No input provided.		
Industry (businesses and business associations)	Differing opinions: • No support for standard monitoring approach across the EU (some MS already have methods in place – double data collection). Quality of data collected by MS should be ensured, though (Cefic). • Support for standardised method for monitoring	No input provided.	No input provided.

	(Eurometeaux, Food Drinks Europe).		
Civil society (NGOs)	Monitoring should assess the soil condition of the slowest reacting soils to detect negative development as soon as possible (BUND Germany).	No input provided.	No input provided.
Research and Academia	Existing monitoring technologies should be applied, with a common set of parameters and no overlap with other EU legislation (Concawe).	No input provided.	LUCAS can be considered () (Concawe). However, in its current states it is considered sufficient as it only samples a limited number of points and those operating it are often not skilled enough in soil science (INRAE).

Summary assessment against indicators

Option 2 may result in a lower administrative burden than other Options as Member States choose their own monitoring parameters and to build upon existing and established soil monitoring frameworks. However, this will inevitably create variability in soil monitoring across the Member States in terms of frequency, information collected and who is responsible for soil monitoring. There may be a distributional impact between Member States, in particular as some currently do not have a soil monitoring programme in place – but this will depend on each Member State and the programme and sampling methods it puts in place. Coherence is neutral to represent the overall importance of soil health monitoring, however Option 2 is not as compatible with other building blocks as options 3 and 4 are.

Table 3-6: Overview of impacts of option 2

Effectiveness	**Impact on soil health**	(+)	No direct impact, but achievement of healthy soils cannot happen if there is no obligation for Member States to regularly and adequately assess the soil health and monitor its status with time, together with the monitoring of the effectiveness of the measures taken. Will influence size of benefits achieved under SSM and REST
	Information, data and common governance on soil health and management	++	Key benefit – obligation on all Member States to monitor will significantly improve data availability. But greater variability (see risks to implementation) in monitoring will lead to lower comparability between Member States in terms of reporting and interpretation of monitoring data, hence benefit lower than Option 3
	Transition to sustainable soil management and restoration	(+)	No direct impact, but fundamental to restoration of soils and will influence size of benefits achieved under SSM and REST
Efficiency	**Benefits**	++	Improvement of data, information and governance key benefit
	Adjustment costs	0	No direct costs, but will influence actions taken and costs under SSM and REST
	Administrative burden	---	Costs of additional monitoring likely to be large (ongoing >EUR 5m pa)
	Distribution of costs and benefits	0	Many Member States already have monitoring systems in place – not certain that additional ambition will vary across Member State relative to status quo
Coherence		+/-	Option less coherent with some options under other building blocks
Risks for implementation		--	Highest risk of inconsistency and a lack of harmonisation in

3.3 MON – Option 3: Most sampling and data collection left to Member States with except for some parameters

3.3.1 Description of option and requirements for implementation

Monitoring Option 3 includes:

- EU to define the method for setting the sampling points and sampling strategies in a soil district (time, seasonality, depth), ***for all soil health descriptors*** in the 'minimum list' (defined in the thematic area Soil Health)
- It is optional to the Member States to use the methods defined by the EU. If Member States choose not to use the methodology defined by the EU, they are required to develop transfer functions to LUCAS (or use those available from science) for all descriptors to translate the measured values into values consistent with LUCAS soil methods
- Member States to define the method for setting the sampling points and sampling strategies in a soil district (time, seasonality, frequency, depth), for all other soil health descriptors in the 'minimum list' (defined in the thematic area Soil Health).

3.3.2 Assessment of impacts

Economic – Option 3

A key difference in impacts driven by the specific elements of Option 3 is around the ***administrative burden***. In practice the overall administrative burden under Option 3 may be greater than that under Option 2 as where the EC determines the sampling method for a number of descriptors under Option 3, this gives Member States less flexibility around the design and application of their monitoring programme overall and would drive a more consistent standard across Member States. Where some Member States may have chosen a lighter touch (and hence less costly, but also less effective) monitoring method for some descriptors under Option 2, the EC's actions to define a common sampling method under Option 3 may drive some Member States to go further than they otherwise would have under Option 2, leading to a higher cost but also a more effective and consistent monitoring regime.

Estimating additional administrative burden is challenging. In particular as it is uncertain how many sampling points will be required per district, and to what extent sampling would need to be expanded at existing sampling points (e.g. for biodiversity, or density). For those descriptors where the EC sets the sampling strategy, it is possible that a denser grid will be required.

An illustrative estimate of additional administrative burden places the cost at around EUR 7.16m upfront, and EUR 40.3m on an ongoing basis for Member States. This estimated is based on all Member States deploying a geostatistically-determined sampling network that would be able to assess soil health with an error of 5%, and deploying a testing regime that will cover all soil health indicators. There would be a medium level of administrative burden (2.2 FTE and EUR 30,000 reference materials) for Member States to setup transfer functions of soil health measurement results to LUCAS and conduct the related laboratory work. Upfront administrative burden would also result from Member States defining the sampling strategy for those elements not harmonised EU-wide and to provide training for those elements which are harmonised EU-wide (2.5 FTE or EUR 3.38 m). Further details on the administrative burdens of the monitoring interventions can be found in section 6.

Table 3-7: Total administrative burden across MON options

Option number	EC – One-off costs	EC – Recurrent costs	MS – One-off costs	MS – Recurrent costs	Other – One-off costs	Other – Recurrent costs	TOTAL – one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 3	54,000	89,000	480,000	42,000,000	-	-	530,000	42,000,000

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

Environmental

No difference in assessment to those assessed for Option 2.

Social

Through the investment in additional monitoring networks and the processing and reporting of data, this option will also have a positive impact on ***employment***. Based on the additional administrative burden to implement a reliable monitoring network under Option 3, it is estimated that this could lead to a direct employment effect of an additional 360 FTEs on an ongoing basis. There will also be additional indirect and induced employment effects as the impacts ripple through the economy. Although more uncertain than the estimate of direct effects, an estimate of the total employment effects is around 480 additional FTE jobs on an ongoing basis. Further detail of the approach and results to estimating employment effects is presented in section 10.

Otherwise, no difference in assessment to those assessed for Option 2.

3.3.3 Distribution of effects

The total number of monitoring points will be proportional to the size of each Member State, soil homogeneity and their use of soil (which is associated with population density). This variability between Member States will mean that some Member States will require more monitoring points than others which will impact the burden of monitoring costs across the Member States. It is challenging to conclude how important the distributional impact will be as Member States who already have a monitoring system in place will be required to go further, and Member States who currently do not have any monitoring will need to develop and implement their own systems too.

3.3.4 Risks for implementation

Option 3 shows a lower risk of inconsistency in monitoring standardisation in comparison to Option 2 whilst also reducing the risk surrounding some Member States not having the necessary expertise to develop a monitoring framework. However, even if the European Commission standardises some elements under Option 3, Member States still have flexibility in determining the monitoring procedures and the identification of districts deemed ‘unhealthy’, and as such could still lead to some variation (albeit less than under Option 2) between Member States.

A recognised and important risk of Option 4 is whether it is technically feasible for the EU to be able to determine a common monitoring framework (including sampling strategies) across the EU, this is discussed in more detail under Option 4. However, Option 3 somewhat works around this risk.

Stakeholders highlighted the importance that common strategies/sampling processes are only to be set in a way which does not impact negatively upon existing monitoring systems in the Member States. However other stakeholders detailed the input of the EU to determine common strategies would be progressive and useful and support the idea that only a minimum level of monitoring is defined at EU-level and member states supplement it according to their identified needs.

3.3.5 Links /synergies

Option 3 allows greater flexibility of coherence with other building block Options due to the combination of Member Sate and European Commission input, whereas Option 2 is limited and best suited to Option 2 in other building blocks. That being said,

A small risk remains (smaller than Option 2) that under Option 3 where some monitoring parameters are standardised and some are not, it may be difficult to implement sustainable soil management practices and restoration programmes under Options 4 due to the remaining variation between Member States.

3.3.6 Summary assessment against indicators

Harmonising the methodology for some monitoring parameters EU-wide under Option 3 will enable greater consistency and comparison between Member States than Option 2. Technical complexity under policy option 3 is lower than that in policy option 4 as monitoring the input from Member States will lower the complexity, time and resource required to establish standardised soil health monitoring across the whole of the EU.

Table 3-8: Overview of impacts of option 3

Effectiveness	**Impact on soil health**	(+)	No direct impact, but achievement of healthy soils cannot happen if there is no obligation for Member States to regularly and adequately assess the soil health and monitor its status with time, together with the monitoring of the effectiveness of the measures taken. Will influence size of benefits achieved under SSM and REST
	Information, data and common governance on soil health and management	+++	Key benefit – obligation on all Member States to monitor will significantly improve data availability. Some risks to implementation, but overall risk deemed lowest for Option 3 and hence benefit is likely to be greatest. Deemed beneficial to give Member States some flexibility around elements of the monitoring method to best reflect local specific parameters
	Transition to sustainable soil management and restoration	(+)	No direct impact, but fundamental to restoration of soils and will influence size of benefits achieved under SSM and REST
Efficiency	**Benefits**	+++	Improvement of data, information and governance key benefit
	Adjustment costs	0	No direct costs, but will influence actions taken and costs under SSM and REST
	Administrative burden	---	Costs of additional monitoring likely to be large (ongoing >EUR 5m pa)
	Distribution of costs and benefits	0	Costs for different Member States will depend on varying starting positions and number of districts – not certain that there will be a significant imbalance of additional burden across Member States
Coherence		+	Option fairly coherent with some options under other building blocks
Risks for implementation		-	Some risk of variability between Member States, but lower than Option 2. Some risk of technical complexity for EC, but lower than Option 4.

3.4 MON – Option 4: Monitoring fully harmonised at EU-level

3.4.1 Description of option and requirements for implementation

Monitoring Option 4 includes:

- Mandatory use of EU list of methodologies based on LUCAS, and use of transfer functions for Member States historical data developed by the European Commission
- EU to define the method for setting the sampling points and sampling strategies in a soil district (time, seasonality, depth), for all soil health descriptors in the 'minimum list' (defined in the thematic area Soil Health). EU to develop transfer functions for Member States historical data.

3.4.2 Assessment of impacts

Economic – Option 4

A key difference in impacts relative to the other options under this building block will be for ***administrative burdens***. If the EU are determining monitoring parameters for all Member States under Option 4, this will only occur once in comparison to this being done by each Member State separately under Option 2. This will require significant effort, and research will be required to define a harmonised approach to soil monitoring across the EU that is accepted as being applicable and feasible across every member state.

Estimating additional administrative burden is challenging. In particular as it is uncertain how many sampling points will be required per district, and what additional testing needs to take place at existing sampling points. Where the EC defines the measurement and sampling procedures, it is anticipated that a more extensive monitoring network is likely to be required and that Member States will need to re-establish their Standard Operating Procedure (SOP) for analysis, laboratory instrumentation and training, resulting in a high cost of around 7 FTE per Member State or EUR 9.45m in total.

The JRC produced a geostatistical-determined sample grid that would be able to assess soil health with an error of 5%. The cost of additional monitoring is based on increasing the current sampling network to achieve the geostatistically-determined sampling network, and all deploying a testing regime that will cover all soil health indicators. As a result, the ongoing administrative burden associated with additional sampling required at existing or new sites for Member States is estimated to be EUR 40.3m.

For the EC, the upfront administrative burden is estimated to be high at around (7 FTE or EUR 847,000 for full harmonisation of all sampling methodologies. Low ongoing costs (1 FTE or EUR 121,000 per annum) are also expected for the EC to update the measurement and sampling methodology every 5 years. Further details on the administrative burdens of the monitoring interventions can be found in section 6.

Table 3-9: Total administrative burden across MON options

Option number	EC – One-off costs	EC – Recurrent costs	MS – One-off costs	MS – Recurrent costs	Other – One-off costs	Other – Recurrent costs	TOTAL – one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 4	70,000	150,000	640,000	42,000,000	-	-	710,000	42,000,000

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

Environmental
No difference in assessment to those assessed for Option 2.

Social
No difference in assessment to those assessed for Option 3.

3.4.3 Distribution of effects

If the European commission fully harmonise Monitoring across all Member States building upon LUCAS, there will be a more consistent requirement across Member States as all would need to take action to align with the harmonised requirements. That said, it is challenging to discern a significant distributional effect, as this would depend for each Member State, how different their current monitoring programmes and procedures differ to the EU-wide requirements set.

3.4.4 Risks for implementation

Whilst some stakeholders noted that Option 4 would in theory be the most scientifically sound and drive greatest levels of harmonisation across the EU, several risks were noted associated with its implementation.

A key risk of Option 4 is the complexity of developing a complete set of sampling methods and strategies for all descriptors that will be applicable EU-wide. One manifestation of this risk is that should it be attempted, it may protract and significantly delay the implementation timetable. This was somewhat experienced under the Soil Framework Directive which invested significant time harmonising a monitoring framework that was applicable to a number of soil types. This risk was explored by stakeholders, who highlighted that there are multiple ways to analyse the same soil health descriptor, especially considering the diversity of climate, soil types and land-uses across the EU. Other stakeholders illustrated this complexity through one step of a sampling procedure – defining sampling density: here stakeholders noted that the type of land-use for a specific site will have a strong impact on what an appropriate sampling density would be, where there is significant heterogeneity in land-use across a district, a significant number of samples will be required. As such these factors can only be effectively determined at a location-specific level, hence some flexibility is required. That said, some stakeholders highlighted that some standardisation could be achieved today in the laboratory analysis stage, given ISO standards exist that cover all soil health descriptors on the minimum list.

Some stakeholders highlighted it would be a challenge to fully standardise data collection as Member States currently have their own protocols, and may be reluctant to abandon their existing monitoring frameworks and analytical procedures.

3.4.5 Links /synergies

Harmonising all soil monitoring across the EU through Option 4 allows for greatest consistency and is coherent with Options of other building block such as sustainable soil management and restoration where monitoring is harmonised to achieve a shared target as it is assured the information collected would be sufficient to understand the required results. Furthermore, Option 4 would ensure that sufficient information is gathered to monitor against the sustainable soil management practices or Restoration programs, this indirectly prevents Member States from limiting the activities they need to undertake to maintain or restore soil health. Full monitoring harmonisation across the EU through Option 4 will be influential in determining the size of the economic, environmental and social impacts and costs of other building blocks, in particular the restoration building block.

3.4.6 Summary assessment against indicators

Option 4 is most likely to facilitate the greatest monitoring comparability and consistency every Member State has harmonised monitoring in place to report back to and drive towards the long-term common goal. Nonetheless, there is a significant risk around the complexity, time and resource required to establish standardised soil health monitoring across the whole of the EU. However, Option 4 means that the determination of soil monitoring parameters only occurs once rather than at Member State level (option 2). Administrative burden on Member States under Option 4 has been estimated EUR 6.75m on an ongoing basis which is significantly less than Option 2.

Table 3-10: Overview of impacts of option 4

Effectiveness	**Impact on soil health**	(+)	No direct impact, but achievement of healthy soils cannot happen if there is no obligation for Member States to regularly and adequately assess the soil health and monitor its status with time, together with the monitoring of the effectiveness of the measures taken. Will influence size of benefits achieved under SSM and REST
	Information, data and common governance on soil health and management	++	Key benefit – obligation on all Member States to monitor will significantly improve data availability. But technical complexity (see risks to implementation) in attempting to define methods for all descriptors could lead to prolonged process, hence benefit lower than Option 3
	Transition to sustainable soil management and restoration	(+)	No direct impact, but fundamental to restoration of soils and will influence size of benefits achieved under SSM and REST
Efficiency	**Benefits**	++	Improvement of data, information and governance key benefit
	Adjustment costs	0	No direct costs, but will influence actions taken and costs under SSM and REST
	Administrative burden	---	Costs of additional monitoring likely to be large (ongoing >EUR 5m pa)
	Distribution of costs and benefits	0	Costs for different Member States will depend on varying starting positions and number of districts – not certain that there will be a significant imbalance of additional burden across Member States
Coherence		+	Option coherent with some options under other building blocks
Risks for implementation		--	Complexity and technical feasibility of developing methods

		for all descriptors by EC could lead to prolonged process

4 SUSTAINABLE SOIL MANAGEMENT (SSM)

4.1 Overview

4.1.1 Building block outline

The European Commission seeks to make the sustainable use of soil the new normal. This building block aims to enable the transition to sustainable management of soils across the EU by requiring sustainable soil management (SSM) and exploring the possibilities for its further definition and elements.

4.1.2 Problem(s) that the building block tackles

This building block predominantly aims to tackle both the main problem from the Intervention Logic (Soils in the EU are unhealthy and continue to degrade) and sub problem B (The transition to sustainable soil management in Europe is needed, but not yet happening). There is a need to improve the practices undertaken by urban and rural land managers (URLMs) to prevent further soil degradation (URLMs is used as a catch-all phrase covering farmers, foresters, urban and other land managers responsible for implementing SSM practices). Soil degradation is in part due to a range of drivers related to SSM:

- Principal-agent problems, e.g., tenants who are not incentivised do often not improve soil health.
- Incomplete EU framework to support sustainable soil management.
- EU and national laws do not effectively promote and enforce sustainable soil management in agriculture, urban development, and forestry.
- Lack of awareness of the importance of soil health, ranging from public authorities, to farmers, to civil society.
- Focus on short-term benefits without taking account of future costs. Associated with public authorities to URLMs.
- Income-related drivers, particularly for URLMs, where restricted profit margins can prevent taking up practices more favourable to achieving soil health, especially where these may increase costs or reduce profit.

4.1.3 Baseline

The following table covers the baseline of implemented and planned policies that regulate or impact sustainable soil management in the EU.

Table 4-1: Relevant policies to baseline for SSM

Policy	Relevant Component	Relevance to SSM
Common Agricultural Policy (CAP)	CAP Reform (2023-27)	Efficient soil management is one of the reformed CAP specific objectives (Sos) under the 'environmental care' objective (SO5). It highlights the crucial role that soils play, the need for sustainable soil management, and encourages best soil practices. The table below covers the Sos in detail and relevance to soil health and SSM.
	CAP Strategic Plans (CAP SPs) (from 2023)	Under the new CAP, strategic plans (SPs) will be implemented at national level and address the specific needs of the respective Member States in relation to EU-level objectives, including soil. CAP SPs will include conditionality, eco-schemes, AECCs, and other investment measures such as horizonal support for Agricultural Knowledge Information Systems (AKIS). Additionally, Article 107 and 115 stipulate that CAP SPs should contain an

Policy	Relevant Component	Relevance to SSM
		annex (Annex I) showing how the SP will address recommendations of the Strategic Environmental Assessment (SEA) referred to in Directive 2001/42 (SEA Directive) with justification. Article 139 states that Member States should carry out ex-ante evaluations to improve the CAP SPs, which can incorporate requirements from the SEA Directive.
	Good Agricultural and Environmental Conditions (GAECs) under conditionality	Set out in CAP regulations but defined by Member States. GAEC standards are part of the conditionality and define various mandatory land management practices for agricultural areas under the CAP that seek to maintain soil cover, prevent soil erosion, maintain SOM, and reduce pollution. The table below details GAECs and relevance to soil further.
	Eco-schemes (from 2023)	Under the new CAP, eco-schemes are one instrument to provide stronger incentives for environmentally friendly agricultural practices (e.g. soil conservation, organic farming, carbon farming etc).
	Rural Development Programmes (RDPs)	RDPs enable funding for Member States from the European agricultural fund for rural development (EAFRD), which can support funding soil-related projects in the areas of: fostering knowledge transfer and innovation in agriculture, forestry and rural areas; promoting resource efficiency and supporting the shift toward a low-carbon and climate resilient economy in the agriculture, food and forestry sectors; restoring, preserving and enhancing ecosystems related to agriculture and forestry. RDPs cover funding of agri-environment-climate commitments (AECCs) and other operational programmes.
	Agriculture, Environment and Climate Commitments (AECCs)	A funding scheme that farmers can choose to enrol in and (here) will affect soil management practices based on AECC prescriptions, improving soil structure, protecting soil erosion and reducing fertiliser and pesticide use. This covers agricultural and forestry practices.
	Investment Measures	Under the CAP, some investment measures are centred around improving sustainable soil practices. The extent to which these measures will support soil health depends on how the Member States defined their investments measures, and the extent they go in seeking to improve SSM practices and ultimately soil health. This covers agricultural and certain forestry practices.
Land Use, Land Use Change and Forestry (LULUCF) Regulation	Revised LULUCF regulation	The revised LULUCF Regulation contains new targets for the period between 2026-2030. For example, full accounting for soil carbon may be an incentive for sustainable soil management practices that increase SOC and sequester carbon and deliver other ecosystem services.
Nitrates Directive	Establishment of codes of good agricultural practices	The Nitrates Directive currently has no explicit soil-focused measures, but sustainable soil management practices and measures contribute to its aim. Relevant to soils are the establishment of codes of good agricultural practices, which are voluntary, but include the use of cover crops to prevent nitrate leaching and crop rotations.
	Nitrate Vulnerable Zones (NVZs)	MS must identify NVZs and set action plans to control pollution. Action programmes are to be implemented by land managers.
Floods Directive	Flood Risk Management Plans (FRMPs)	There are no binding or voluntary requirements dedicated to soil. However, the Floods Directive drives Member States implementation of flood management measures under FRMPs, some of which could improve soil management practices, and thus reduce soil erosion and compaction. For example, forestry measures, watercourse re-wiggling, and floodplain expansion.
Water Framework Directive (WFD)	-	Ensures the protection of riparian, river catchment, groundwater, and coastal areas (among others) and seeks to prevent pollution from various activities, which indirectly supports achieving soil health.
Sustainable Use of Pesticides Directive (SUD)	-	Regulates use and application of pesticides in the EU. Specific to soil are consideration on the placement of buffer zones to prevent run-off and groundwater pollution.
National Emissions reduction Commitments Direction (NECD)	Annex III, Part 2: Emissions reduction measures	Relevant to loss of soil quality. Some of the measures under the NECD aim to promote various sustainable soil management practices, such as the replacement of inorganic fertilisers by organic ones or spreading manures and slurries in line with the foreseeable nutrient requirement of the receiving crop or grassland with respect to nitrogen and phosphorous, to prevent soil degradation.
EU Soil Strategy	Objective 3: protecting soils and managing them sustainably (…) is a common standard.	The EU Soil Strategy for 2030 sets out a framework and concrete measures to protect and ensure that they are used sustainably. This includes the preparation of a set of ‘sustainable soil management’ practices and the dissemination of successful sustainable soil and nutrient management solutions.
Strategic Environmental Assessment (SEA) Directive	Article 5	Where SEA assessment is required, the environmental report should contain relevant information, identifying, describing and evaluating the likely significant environmental effects, inter alia, on soil, stemming from implementation of a plan or programme, falling under the scope of the SEA Directive. The environmental report shall include information that may reasonably be required taking into account current knowledge and methods of

Policy	Relevant Component	Relevance to SSM
		assessment, the contents and level of detail in the plan or programme and the extent to which certain matters are more appropriately assessed at different levels in the decision making process in order to avoid duplication of the assessment.
Environmental Impact Assessment (EIA) Directive	Article 3	Under the EIA Directive, the EIA of certain public and private projects should consider, limit, identify, describe and assess their impact on land (incl. Land take) and soil, including considerations of organic matter, erosion, compaction and sealing.
Industrial Emissions Directive (IED)	Article 15	The IED aims to reduce pollution/contamination from industrial activities. Part of the IED covers contamination to soil and/or groundwater and looks to ensure that no further contamination is being caused by industrial processes on-site. However, there are no explicit mentions of SSM practices in the IED.
Forest Strategy	Section 3.2	The Forest Strategy covers several aspects related to SSM practices. Firstly, it seeks to ensure forest restoration and reinforced sustainable forest management for climate adaptation and forest resilience, which includes management practices that support soil health and do not harm soil health, with specific reference to soil erosion, compaction, SOM and SOC.
Birds Directive	Article 3	The Birds Directive contains references to supporting soil health through good management. For example, there are measures such as the upkeep and management in accordance with the ecological needs of habitats inside and outside the protected zones, which can implicitly support soil health depending on what practices are being implemented.
Habitats Directive	Article 6 Article 10	The Habitats Directive contains references to supporting soil health through good management practices. This includes conservation measures to support Specials Areas of Conservation (SACs) and the Natura 2000 network.
National Energy and Climate Plans (NECP) Governance Regulation	Annex I Annex IX	Under the NECP Governance Regulation, Member States must report on nitrogen emissions from soil and area of cultivated organic soils. They must also report on the estimated impact of the production or use of biofuels, bioliquids and biomass fuels on soils within the Member State. Many actions which are relevant to reduce emissions from cropland and soils include the implementation of SSM, e.g. crop rotations, reduced tillage and actions to improve soil carbon. These actions which can improve nutrient cycling and management can have important impacts upon nitrous oxide, and methane emissions.
Renewable Energy Directive (RED) II	Article 10 Article 29	Under Article 10 of RED II, it is stated that agricultural feedstock for the production of biofuels, bioliquids and biomass fuels should be produced using practices that are consistent with the protection of soil quality and soil organic carbon. Under Article 29, the harvesting of forest biomass must be carried out considering maintenance of soil quality and biodiversity with the aim of minimising negative impacts.
Biodiversity Strategy	-	The EU Biodiversity Strategy seeks to support and improve biodiversity within the EU and prevent the loss of biodiversity seen on a massive scale global. Actions to support biodiversity are often indirectly complementary towards improving soil health in agricultural, forested and urban areas. A key part of the strategy is to promote healthy and vibrant urban ecosystems, aiming to stop the loss of and increase green urban space, which can indirectly support soil health in urban areas.

Table 4-2: CAP strategic objectives (Sos) and their relevance to SSM practices and soil health[478]

SO	Description	Relevance to SSM and soil health
1	Ensure a fair income for farmers	N/A
2	Increase competitiveness	Improvements in soil health can provide direct benefits in productivity, through improved yield, reduced costs and improved resilience of crops.
3	Improve the position of farmers in the food chain	N/A
4	Climate change action	This SO examines the role that agriculture can play in the reduction of greenhouse gas emissions through new farm and soil management techniques.
5	Environmental care and efficient natural resource management	This SO focuses on soil as one of the most important natural resources, supplying essential nutrients, water, oxygen and support for plants. It also examines concerns related to soil health and highlights the importance of policies which promote soil protection.
6	Preserve landscapes and biodiversity	Actions that seek to preserving landscapes and biodiversity will likely indirectly support soil health through a range of conservation related practices.
7	Support generational renewal	N/A
8	Vibrant rural areas	N/A
9	Protect food and health quality; and animal welfare, food waste and loss, antimicrobial resistance	On-farm actions that seek to protect food and health quality will likely indirectly support soil health through various practices.
10	Fostering knowledge and innovation	Funding for projects and programmes that enable the research and development of innovative SSM practices and dissemination of knowledge can help farmers achieve soil health.

At EU level, there is no dedicated soil policy with binding requirements for land owners and managers to implement a comprehensive set of sustainable soil management practices across agricultural, forestry, urban, and other land uses. In its place, there is a set of policies targeting agriculture, water protection, nutrient management, planning, and flood risk management that have an effect on the way soils are managed (although soil protection is not always an explicit objective of these policies).

Currently, the CAP is the most targeted policy in terms of supporting soil health in agricultural areas through conditionality, eco-schemes, and AECCs. Three out of nine GAEC standards (see table below) are focused specifically on soil health, and with others indirectly supporting soil health. The CAP GAEC standards as of 2023 are estimated to cover up to 90% of agricultural land in the EU,[479] meaning that farm holdings within this area receive payments for maintaining good standards of farming, but leaving 10% of agricultural land not under the CAP and all non-agricultural land with fewer protections and with less encouragement to deploy SSM practices.

Table 4-3: GAECs in the 2023 CAP iteration[480]

GAEC	Description	Aim	Main Focus
1	Maintenance of permanent grassland based on a ratio of permanent grassland in relation to agricultural area at national, regional, sub-regional, group-of-holdings or holding level in comparison to the reference year 2018. Maximum decrease of	Preserve carbon stocks	Climate change (mitigation and adaptation)

[478] Key policy objectives of the new CAP (europa.eu)
[479] EC Communication (2022): Common agricultural policy for 2023-2027. 28 CAP Strategic Plans at a glance. https://agriculture.ec.europa.eu/system/files/2022-12/csp-at-a-glance-eu-countries_en.pdf
[480] gov.ie - The CAP Strategic Plan 2023-2027 (www.gov.ie)

	5% compared to the reference year		
2	Protection of wetland and peatland	Protection of carbon-rich soils	Climate change (mitigation and adaptation)
3	Ban on burning arable stubble, except for plant health reasons	Maintenance of soil organic matter	Climate change (mitigation and adaptation)
4	Establishment of buffer strips along water courses	Protection of rivers courses against pollution and run-off	Water
5	Tillage management reducing the risk of soil degradation, including slope consideration	Limit soil erosion	Soil (protection and quality)
6	Minimum soil cover to avoid bare soil in periods that are most sensitive	Protection of soils in most sensitive periods	Soil (protection and quality)
7	Crop rotation in arable land, except for crops growing under water	Preserve soil potential	Soil (protection and quality)
8	Minimum share of agricultural area devoted to non-productive features or areas – Retention of landscape features – Ban on cutting hedges and trees during the bird breeding and rearing season	Improve on-farm biodiversity	Biodiversity (protection and quality)
9	Ban on converting or ploughing permanent grassland designated as environmentally-sensitive permanent grassland in Natura 2000 sites	Protection of habitats and species	Biodiversity (protection and quality)

With regard to forestry, there are various mentions within the EU Forestry Strategy on improving forestry management practices, of which many will relate to specific soil pressures such as erosion, compaction, vegetative and biological diversity, and loss of SOM. Under the CAP, some AECCs and investment measures are centred around improving sustainable forestry practices. However, any improvement will depend on how the Member States define their AECCs and investment measures, and the extent/ambition they go in seeking to improve forestry practices and those related to SSM.

Urban soils are more complex due to the specific pressures on urban soils. Urban soils are particularly impacted by land take, contamination, soil sealing, and excavation, which are pressures covered under other building blocks, such as REM, LATA, CERT and PASS. Pressures on urban soils come from a range of actors, such as developers, construction, utilities and others. With regard to SSM, current EU planning policy protects urban soils under the EIA Directive and the Birds and Habitats Directives, although the latter two have indirect impacts on the protection of soils.

Outside the CAP, there are various policies and programmes at the Member States-level that seek to protect and achieve soil health, such as the German Federal Soil Protection Act, which aims to protect and restore soils functions and includes precautions against negative impacts on soil, and sets out principles for agricultural practices (e.g., land and soil must be used appropriately as per location and weather conditions), and the Agricultural Code of Wallonia, Belgium, where soil is directly mentioned as a natural resource to protect and manage. While other policies and directives, such as the Nitrates Directive, WFD, SUD, IED and NECD, EIA Directive and the Habitat and Birds Directives go some way in supporting soil health through voluntary or implicit good SSM practices across agricultural, forestry and urban areas, there is a lack of explicit control on practices that will harm soil health and prescription on practices that will promote soil health across all 27 Member States. Consequently, there is a need for the Soil Health Law to encourage or prescribe good SSM practices with the aim of improving all indicators of soil health now and in the future.

4.2 SSM – Option 2: Obligation to use soils sustainably; definition of principles and practices is left to Member States

4.2.1 Description of option and requirements for implementation

All options under SSM contain the following:

- The SHL provides a common definition of sustainable soil management and includes the obligation to use soil sustainably

Option 2 specifically also includes the following:

- The SHL provides an indicative list of SSM principles and practices (Member States can go beyond the list, no elements are mandatory).

In response to the elements of the legislation as defined above, URLMs must implement the sustainable soil management options further defined by Member States. URLMs is used as a catch-all phrase covering farmers, foresters, urban and other land managers responsible for implementing SSM practices.

In response to the OPC, there was a strong agreement across all stakeholder types that there should be a legal obligation for Member States to set requirements for the sustainable use of soil so that its capacity to produce food, filtrate water, host and support biodiversity, store carbon etc. is not hampered. 89% of all respondents 'totally agreed' this obligation should be put in place, with a further 8% 'somewhat agreeing'. 'Totally agree' was also the most common (or joint most common in the case of Trade Unions) response across all stakeholder types.

There are several uncertainties for implementation for this option. Firstly, which principles will be included in the indicative annex to the SHL. Secondly, what principles from this list the Member States will seek to include within their national legislation, and how these will be set out: e.g. whether they are obligatory or voluntary, whether there are exemptions based on income or location, etc. Finally, depending on the extent of practices that Member States chose to use, there will also be uncertainty around which measures (particularly voluntary ones) will be implemented, to what extent and in what areas.

How the SHL defines SSM will provide the basis for the principles and practices included within this option and others. Stakeholders noted that the definition of 'sustainable management' must take an approach that considers how soils differ in their response to management practices, their ability to provide ecosystem services, their resilience to disturbance, and their vulnerability to degradation. They also suggested that the SHL should include a Code of Practices for Sustainable Use of Soil for different land uses for its definition of SSM.

4.2.2 Assessment of impacts

The impacts of SSM, as well as REM and REST, will have significant overlap as these will both involve similar principles of changing existing soil management with the objective of improving soil health. Reading through the impacts of SSM practices should be read in conjunction with the REST impacts.

Economic

There are a wide range of principles and resulting practices which contribute to SSM (and equally multiple practices that can be defined as harmful). They differ in their type, nature and the soil threats they work against. SSM practices exist for agricultural, forest and urban soils (and in many cases practices can be applied across two or all three areas). An initial list of SSM (and harmful) practice examples are included in section 9.

There will be costs associated with implementing SSM practices associated with upgrading equipment and facilities or using alternative inputs of production – it is uncertain where these costs will fall and in what proportion, as this will be determined by the methods chosen by each Member State to drive adoption. However, the obligation to use soils sustainably falls to Member States and as such, this is where the costs will initially fall ***(Public authority budgets)***. Implementation of SSMs could also drive economic benefits (through for example raw material input savings). Hence implementing SSM practices could impact the profit to businesses or industries affected. As noted in the limitations section, existing evidence for the costs and benefits of different SSM practices is incomplete, with many studies focusing on very specific practices, localities and conditions – as such it has not been possible to produce a comprehensive estimate of the costs of the options under this building block. This section proceeds instead to review the good level of evidence at a localised level for the costs (and benefits) of SSM, before presenting an illustrative set of EU-wide costs (and benefits) associated with a sample of measures.

Soil threats such as erosion, compaction and salinisation that can result from natural or anthropogenic drivers can result in the deterioration of soil functions and reduce soil health. Conserving soil's natural capital[481] provides benefits to farmers and land mangers through higher yields and lower fertiliser needs or ensures that soils can function properly in both urban and rural areas. Furthermore, many agricultural SSM practices encourage diversification of the farm system (crop rotations, conversion of arable to pasture, set aside, intercropping), which then in turn diversifies the output, and therefore income streams. This could make the farm more resilient to outside fluctuations in climate, market prices, supply-demand etc.[482]

In general, the initial uptake of soil-friendly practices can be very costly, which is often a deterrence to URLMs seeking to adopt such practices.

Studies exploring the economic impacts of specific principles

Several studies have explored the economic costs, benefits and the trade-offs associated with SSM practices.

The 2018 RECARE Impact Assessment[483] assessed a range of case study examples from across the EU, considering the impacts resulting from varying ambitions[484] of soil management practices. The RECARE assessment identifies a wide range of SSM practices applicable to different Member States, different land use systems, and different

[481] Soil is one of the Earth's most important natural capital assets. Soil natural capital includes a range of properties and processes associated with the physical and biochemical components of soil, as well as the diversity of micro-, meso-, and macrofauna that inhabit soils. Soil provides an extensive range of functions and ecosystem services, such as regulating, provisioning, and cultural services for humans and wildlife.

[482] A. Alaoui & G. Schwilch, 2019. Database of currently applied and promising agricultural management practices. iSQAPER.

[483] (PDF) Integrated impact assessment of European soil protection policies (researchgate.net)

[484] RECARE noted that common definitions of what is low, medium and high ambition were difficult to define given the project covered a number of soil threats in different parts of Europe, with different soil conditions and different socioeconomic circumstances.

soil pressures. The table below provides examples of these levels of ambition based on practices undertaken in the assessed Member State. To note, a more extensive list of practices can be found in section 9. The difference in ambition is in part due to the cost associated with the practices; higher ambition sustainable management practices (SMPs) were considered generally to come with high CAPEX costs compared to low ambition SMPs. For example, monoculture crops are a much cheaper method of arable farming in comparison to cover crops being sown in, which is a more costly and ambitions way of farming, and one which has greater benefits for SOM and soil health.

However, medium ambition SMPs also often lead to high CAPEX – similar to, or in some instances even higher than, investment cost of high ambition SMPs. When considering SSM practices, OPEX can be just as important as CAPEX. It is important to note that total CAPEX and total OPEX per ha differ very much between case studies and between Member States, thus making it difficult to provide conclusive quantitative cost data that is applicable across Member States and practices. This highlights the limitations of not only this study (RECARE) but with limitations faced in assessing the economic impacts of SSM practices more generally.

The second table below provides details on the countries, areas, and soil threats analysed in the 2018 impact assessment.

Table 4-4: Examples of sustainable soil management practices for low, medium, and higher ambition categories from a range of case study examples from Member States in the EU. Adapted from RECARE (2018). These practices cover agricultural, forested, and urban area

Threat	MS	Low Ambition	Medium Ambition	Higher Ambition
Erosion – water	PT	Post-fire salvage logging	Implementation of forest residues barriers	Mulching
	SW	-	-	No till/ mulch tillage/ strip tillage
	CY	No action	Good agricultural and environmental management of land, but poor implementation	Maintenance of existing field margins (dry-stone walls) in agricultural land
Erosion – wind	ES	Conventional tillage	No tillage, catch/cover crops	No tillage with straw mulch, catch/cover crops and straw mulch
	IS	Grazing on poorly vegetated or newly seeded land; continuous communal land grazing in highlands, throughout summer	Continuous communal land grazing in highlands, throughout summer	Lowland grazing; good control of biomass; ability to move animals as needed; Land grazed one year and rested for one to two years
Loss of SOM – mineral	IT	Crop management with monoculture	Organic farming; input of organic amendments	Conservation agriculture; cover crops

Threat	MS	Low Ambition	Medium Ambition	Higher Ambition
	NL	Catch crops; decreasing the period in which grassland can be destroyed	Catch crops and land use change from silage maize to grassland	Catch crops and land use change from silage maize to grassland, and early seeding of catch crops in maize
Loss of SOM – organic	SE	Status quo – all different crops grown	Growing water intolerant crops such as Reed canary grass without increase in GHG emissions	Conversion to wetlands (no agricultural production)
	NL	-	Ditchwater level less than 60cm below soil surface	Use of submerged drains
Flooding	SK	Row crops, high density planting, conventional tillage	Grassland; Special agrotechnical measures; Green manures; Strip cropping	Vegetative strips; Water retaining ditches; Small wooden check dams; Polders
	NO	No action	Grass covered waterways	Retention ponds
Contamination	RO	Natural attenuation/ no cultivation; Crop rotation; Applying mineral and organic fertilizers	Liming applying manures and compost; Cultivation of biofuel crops or energy forestry	Appling (inorganic) amendments in order to reduce the transfer of metals in crops; Afforestation; Remediation of contaminated soils (phytoremediation, decontamination)
	ES	Pollution extraction; Grazing of horses	Natural assisted remediation; Adequate soil use	Afforestation; Amendment addition; Removing sludge from mine-spill
Salinisation	EL	Irrigation with groundwater	Rainwater harvesting	Biological soil amendments, and rainwater harvesting

Note: PT – Portugal; SW – Switzerland; CY – Cyprus; ES – Spain; IS – Iceland; IT – Italy; NL – Netherlands; SE – Sweden; SK – Slovakia; NO – Norway; RO – Romania; EL – Crete.

Table 4-5: Case studies covered in the 2018 RECARE Impact Assessment. Adapted from RECARE (2018).

Case study	Soil threat	No of interviews
Frienisberg, Switzerland	Soil erosion by water	8
Caramulo, Portugal	Soil erosion by water	10
Peristerona, Cyprus	Soil erosion by water	10
Timbaki, Crete	Salinisation	7
Aarsley, Denmark	Compaction	-
Canyoles, Spain	Soil Erosion by wind	6
Grunnarsholt, Iceland	Desertification	8
Poznan and Wroclaw, Poland	Flooding	3
Vansjo-Hobol, Norway	Floods and landslides	9
Myjava, Slovakia	Floods	8
Veenweidegebeid, Netherland	Loss of SOM in organic soils	8
Broddbo, Sweden	Loss of SOM in organic soils	3
Olden Eibergen, Netherland	Loss of SOM in mineral soils	7
Veneto, Italy	Loss of SOM in mineral soils	6
Guadiamar, Spain	Contamination	8
Copsa Mica, Romania	Contamination	7

SSM can also deliver short-term, direct benefits to the URLMs. In the RECARE project, higher ambition agricultural SSM practices were identified as also delivering higher yields. In general, the positive impacts of SSM practices on yields depends on soil type, the initial content of organic matter and type of crop. For example, significantly higher yields with no till could be achieved for cereal and legumes, while it would lead to lower yields when applied to potatoes and sugar beets[485]. Without combination with other management practices, e.g. coverage/residue retention, reduce tillage (RT) can reduce yields[486]. Yield increases in response to higher soil organic carbon (SOC) and/or fertiliser input rates, but additional increase increments in SOC or fertiliser give progressively smaller increments in yield[487]. A higher SOC can result in higher yield and higher marginal revenue at the constant N application rate. This saves farmer's money by reducing the risk of nutrient leaching (and hence having to replace with N application), while also reducing the risk of emissions of nitrous oxide from denitrification and carbon dioxide from manufacture/transport[488].

Another study which explored the economic impacts of SSM practices is Rejesus et al.[489]. The table below highlights a range of economic benefits and costs related to the implementation of various SSM practices. The use of various practices can improve soil conditions (relative to a benchmark of soil health) and may lead to improved economic private and public benefits. The benefits and costs in the table below are split by public and private benefits/costs.

Although some benefits are defined as 'environmental' in the short term, in the long-term these may provide a societal economic benefit. For example, increased carbon sequestration potential will reduce costs in the long term through their impact on the risk often related to climatic changes and may enable farmers to diversify their businesses and harness carbon sequestration as a separate income stream through carbon farming initiatives, where available. It should be noted that in the table below, reference to cover crops and tillage are examples of a wider group of measures. (Note: The table below from Rejesus et al. only answers part of the issues addressed under SSM building block. It does not make specific reference to the practices many associated with forestry management and urban areas, which were not covered by the study).

Table 4-6: Economic dimensions of SSM practice decisions, adapted from Rejesus et al.

Type	Potential Benefits (revenue increasing or cost decreasing)	Potential Costs (revenue decreasing or cost increasing)
	Agronomic	
Private (e.g., individual)	Increase yields (and revenues) Reduced fertilizer expenses Reduced fuel costs (in no-till) Better resilience to extreme weather events Yield stability over time Grazing opportunities (from cover crops)	Increased cover crop costs Increased labour and machinery costs (OPEX) (e.g., for planting cover crops) Increased herbicide costs (e.g., for cover crop termination and weeds in no-till systems) Decreased yield (e.g., if delayed planting due to delayed cover crop termination) Opportunity cost of labour for planting cover crops in the winter Decreased moisture available for cash crop (after planting

[485] RECARE IA 2018
[486] How does tillage intensity affect soil organic carbon? A systematic review protocol | Environmental Evidence | Full Text (biomedcentral.com)
[487] Sustainability | Free Full-Text | Roadmap for Valuing Soil Ecosystem Services to Inform Multi-Level Decision-Making in Agriculture (mdpi.com)
[488] *Ibid.*
[489] Economic dimensions of soil health practices that sequester carbon: Promising research directions (jswconline.org)

Type	Potential Benefits (revenue increasing or cost decreasing)	Potential Costs (revenue decreasing or cost increasing)
		cover crops) May recruit unwanted wildlife (for cover crops)
External (e.g., societal)	Agronomic	
	Reduced pest and disease outbreak incidence (e.g., due to beneficial insects), which can enable more stable food supply	Increased pest or disease incidence for neighbours due to cover crops being a possible host

With regard to agricultural soils, greening obligations under the former CAP (such as ensuring 5% of land is set aside as an ecological focus areas (EFA) where environmental and climate-focused measures are to be implemented) have been noted to have the potential to reduce farm incomes in the short term, which is down to a result of lost production or constrained production choices. However, analysis from a previous EU evaluation shows that this has happened little in practice.[490] Further, the reality of improving soil fertility ensures that yields become more stable, increasing profit, and there are reduced costs for fertilisers and pesticide use, decreasing costs. This is particularly evident in the longer term.

Brady et al.'s study on valuing soil ecosystem services[491] assessed a range of alterative agricultural SSM practices in Sweden (the specific practices are not listed in the paper however they are centred around climate mitigation through carbon storage and reduced GHGs, water quality improvement through nutrient retention, and conservation of soil natural capital and soil productivity). Simulations provided from this study predict that at the farm-level, an annual 1% relative increase in the stock of soil natural capital delivered through improved management practices over a period of 20 years would result in 18% increase in the average farm's gross margin during the same period. The study also noted that the long-term impacts of (dis)investing in soil natural capital are substantial compared to the short-term impacts, which are small. This is an important consideration for farmers and land managers investing in soil health, as the economic benefits will not be seen for some years.

For agricultural measures targeting erosion specifically, such as reduced or no tillage or vegetative barriers, the production costs for farmers may increase in the short-to-medium term[492]. However, production costs are reduced in the longer term due to higher soil productivity. Nevertheless, farmers may receive compensations for specific measures (e.g. under agri-environment or other Rural Development measures). Reducing or preventing erosion through SSM measures can lead to:

- Additional and up-front investments in soil conservation will lead to long-term increase and maintenance in soil productivity, and consequently an increase in yield in the longer term. In the short term some measures (e.g. no tillage (NT) or measures against compaction) may enable some savings for farmers (e.g., resulting from less use of fuel and machinery).[493]
- Positive off-site effects on water infrastructure, especially dams and other water reservoirs, due to less sedimentation resulting in reduced dredging costs and maintenance costs.[494]

490 Evaluation of the Impact of the CAP on Habitats, Landscapes, Biodiversity (ecologic.eu)
491 Sustainability | Free Full-Text | Roadmap for Valuing Soil Ecosystem Services to Inform Multi-Level Decision-Making in Agriculture (mdpi.com)
492 EUR-Lex - 52006SC1165 - EN - EUR-Lex (europa.eu)
493 *Ibid.*
494 *Ibid.*

- Less water treatment required due to lower sediment load and reduced contamination, resulting in lower OPEX.[495]

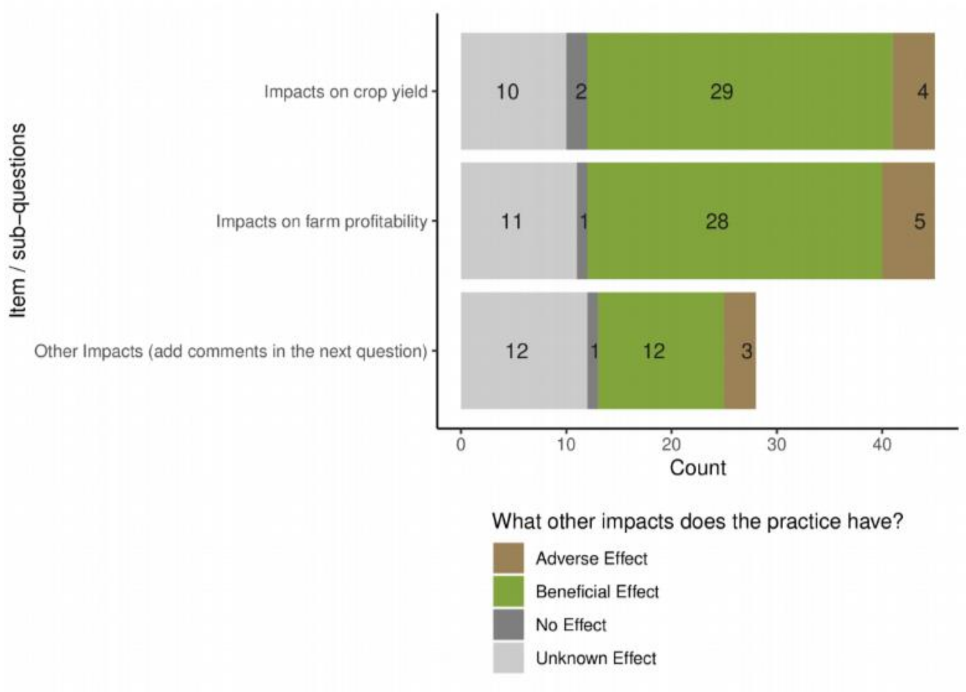
The potential for short term benefit to the agricultural land managers and owner in terms of yield increase or input cost saving is uncertain, and will depend on the specific measure, conditions of implementation, extent of implementation, etc. In some extreme cases, the additional costs of adopting SSM may pose an increased risk some urban and rural land managers that their operations become no longer economically viable. In particular given some of the key sectors likely affected (e.g. agriculture) are highly exposed due the structure of businesses and the ability to cope with significant capital investments or shocks in financial performance. However, this risk is also significantly influenced by the delivery mechanism selected by Member States and how much of the cost is passed onto private actors and what other support (e.g. funding) may be provided. Furthermore, the substantial economic benefit from implementing SSM practices comes in the avoidance of future harms in the medium and longer-term, that current unsustainable management practices are driving towards. In addition, many agricultural SSM practices encourage diversification of the farm system (crop rotations, conversion of arable to pasture, set aside, intercropping), which then in turn diversifies the output, and therefore income streams. This could make the farm more resilient to outside fluctuations in climate, market prices, supply-demand, etc.[496]

Estimates vary in terms of the size of the potential longer term cost of unsustainable practices (and hence the 'avoided cost' – or benefit – of adopting SSM), it is also uncertain to what extent SSM will avoid these costs if deployed at different scales, but the sheer size of the potential harm overall suggests that even if SSM were to capture a proportion of these benefits, there would be a reasonable offset to the costs of implementing such measures.

The EJP's study on innovative soil management practices across Europe[497] assessed a wide range of 58 different SSM practices used in Europe across different agricultural, forestry, and other land use systems. The figure below presents the potential impact of the practices taken into account in this study on pressures to soil (such erosion, compaction, salinisation, etc). It was found that most practices have a beneficial effect on crop yields and on farm profitability. Most SSM practices that can be undertaken by agricultural land managers are likely to have a positive impact on crop yield, and therefore profitability. However, it should be noted that some practices may have an adverse economic effect, particularly when applied to a particular land use type or soil type where the practice is not suitable and equates to a waste of investment in the practice, or damaged the soil or environment to such an extent that the soil productivity is greatly reduced.

[495] *Ibid.*
[496] A. Alaoui & G. Schwilch, 2019. Database of currently applied and promising agricultural management practices. iSQAPER.
[497] Details on the study and the list of SSM practices assessed can be found here: Innovative soil management practices across Europe (ejpsoil.eu)

Figure 4-1: Potential effects on crop yield and farm profitability from the list of practices covered in the study



Source: EJP Soils

In addition, several studies and tools funded under the LIFE Programme illustrate the economic impacts of implementing various SSM practices.

Information box – studies and tools funded under the LIFE Programme

Previous studies and tools funded under the LIFE Programme can provide examples of the cost of implementing various SSM practices across the EU. For example, a softer measure that can support achieving soil health is the inclusion of education and training for farmers, land managers and foresters to learn about soil health and the necessary practices to support it. With funding from LIFE, LIFE DEMETER developed a tool, the Decision Support System (DSS), for farmers and their advisors to optimise nutrient and organic matter management simultaneously at field level. Based on the number of active accounts by the end of the project, the DSS was used by 700 farmers and advisors. To date, the number of active accounts increased to some 1,200, mainly in Flanders (>90%) and also in the Netherlands (<10%). The total estimated costs for concrete actions towards soils totalled €966,200, meaning that each account cost just below €1,000. Agricultural stakeholders found the DSS useful to increase awareness amongst farmers about SSM that will maintain or increase soil organic matter whilst minimising nutrient loss risks. Over a time span of 30 years, use of the Demeter tool is expected to upgrade the soils of about 1,200 users to an optimal SOM content. This will result in an increase of crop production in the range of 5%.[498]

Another similar project funded through LIFE that focused on SSM and groundwater protection, this time in Spain, was focused on avoiding water eutrophication and reducing soil erosion in a 276 ha olive grove in Spain. This was soil-related by

[498] This benefit has not been transposed into euros / net present value.

considering advisory services, awareness and training for farmers (individual advice, training seminars, edition of informative material), in order to promote good agricultural practices, such as the maintenance of vegetation cover (avoiding soil loss) and avoiding the over fertilising (reducing the pollution risk). It was reported a reduction of 32% of fertilisers in average for the farms collaborating with the project. Further, the project showed to be cost-efficient for avoiding the erosion – the results showed that vegetative coverage, if duly managed, does not entail any cost or reduction in the agricultural productivity.

In the same vein, another project aimed to minimise the extent of nutrient excess in soils caused by the pig farming sector, by promoting and testing some good practices at livestock, arable land and agroforestry levels in Spain. The project advised farmers on fertiliser-related concerns on an area of 1,200 hectares irrigated cereal crops, focusing on the implementation of computing tools for decision making in initial fertilisation stages; study of advanced techniques for manure application; and the optimisation of manure application through Best Available Techniques (BAT). Taking into consideration the prices of mineral fertilisers and the average content of nutrients of the manure, it was calculated that the economic value of the fertilisers ranged from 14€/m3 to 28 €/m3, depending on the source. This entails direct savings for on-farm sources counting with both arable and livestock farms. Furthermore, for arable farmers applying manure from external sources, the savings were found to be around 20 €/ha.

Finally, the HelpSoil project tested innovative solutions and demonstrated SSM practices to improve soil quality and to make agricultural systems more resilient against climate change. The project was implemented in Northern Italy in areas of the Po plain and the Apennine foot-hills, on 20 experimental farms over three growing seasons. The overall cost of the soil-related actions that were implemented during the project amounted to €1.2m. According to the farmers involved, the project is expected to generate significant socio-economic benefits, as it promotes techniques which allow the cultivation of crops using fewer chemicals and machinery. This maintained the economic efficiency of the farms at a standard factor of 2.4, which increased to a factor of 4 from the third year onwards. This might lead to reduced expenses (in the range of 20-30%, but the saving tends to increase over the years) and therefore it can be considered a financial support to farmers involved in the project.

Studies exploring the total cost of (and hence benefits of principles acting on) specific threats

A number of studies have attempted to assess, quantify and monetise the costs of soil degradation. The 2006 Impact Assessment of the Thematic Strategy On Soil Protection[499] assessed the on-site and off-site impacts of eight soil-threats – a summary of the analysis is contained in the following information box. This section summaries and reviews more recent evidence on the costs of different soil threats, before proposing several updates to the aggregate cost estimate.

[499] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52006SC0620&from=EN

Information box – summary of the analysis of costs of degradation contained in the 2006 Impact Assessment

The 2006 Impact Assessment of the Thematic Strategy On Soil Protection assessed the on-site and off-site impacts of eight soil-threats. Some of the impacts were quantified as part of the assessment, whereas other impacts were assessed qualitatively. A summary of the analysis, the on-site and off-site effects identified associated with each soil threat (including an indication of which were quantified), and quantified impact in the 2006 report are summarised in the following table.

Table 4-7: Summary of analysis in the 2006 Impact Assessment

Soil threat	On-site effect	Off-site effect	Quantified impact (2003 prices)
Erosion	- Yield losses due to eroded fertile land** - On-site costs due to impact on tourism	- Costs of sediment removal, treatment and disposal** - Costs due to infrastructure (roads, dams and water supply) and property damage caused by sediments run off and flooding** - Costs due to necessary treatment of water (surface, groundwater)** - Costs due to damage to recreational functions** - Economic effects due to erosion-induced income losses - Costs due to increased sediment load for surface waters (e.g. negative effects on aquatic species, difficulties for navigation) - Costs of healthcare caused by higher exposure to dust and soil particles in the air	€0.7 – 14.0 billion If long term effects (20 years) of soil erosion are taken into account, the estimated on-site costs, i.e. around €800 million would become €3.25 billion
Decline of soil organic matter (SOM)	- Yield losses due to reduced soil fertility**	- Costs related to an increased release of greenhouse gases from soil** - Costs due to loss of biodiversity and biological activity in soil (affecting fertility, nutrient cycles and genetic resources)	Annual on-site costs (mainly due to lower soil productivity) of SOM decline have been estimated to be around €2 billion. For the off-site effects, estimated the annual costs for society derived from the carbon released annually from soils due to the decline of SOM to be between €1.4 and 3.6 billion. The total annual costs of non-action for SOM decline have thus been estimated to be between €3.4-5.6 billion.
Compaction	- Yield losses due to reduced soil fertility and increased vulnerability of crops to diseases as a consequence of worsened growing conditions	- Costs due to reduced water infiltration into the soil - Costs due to increased leaching of soil nitrogen - Costs linked to increased emissions of greenhouse gases due to poor aeration of soil	No quantitative estimates of the total costs could be produced.
Salinisation	- Yield losses due to reduce soil fertility**	- Costs due to damage to transport infrastructure (roads and bridges) from shallow saline groundwater** - Costs due to damage to water supply infrastructure** - Environmental costs, including impacts on native vegetation, riparian ecosystems and wetlands** - Costs due to negative effects on tourism	The total costs, regarding salinisation for three countries (Spain, Hungary, Bulgaria) have been estimated to be between €158 and 321 million per year. Extrapolation at EU level was not considered possible.
Landslides	- The loss of topsoil, leading to a loss of productive soil and hence a decrease in crop yield - Damage to on-site infrastructures	- Impact on human lives and well-being - Damage to property and infrastructure - Indirect negative effects on economic activities due to interruption of f.i. transport routes - Ruptures of underground pipelines, dislocation of storage tanks, release of chemicals stored at ground level and contamination of surface waters with associated off-site costs as described already under erosion	The extrapolation of the costs of landslides is not possible in the same way as for other soil threats, which occur continuously and are more widely-spread. Up to €1.2 billion per event
Contamination	- Costs of monitoring measures and impact assessment studies that must be carried out in order	- Costs of increased health care needs for people affected by contamination, which include the treatment of patients and the monitoring of their health during long periods to detect the effects of exposure to soil contamination**	Total estimated costs range from EUR 2.4 pm to 208bn pa. These estimates, and in particular the big difference between the

Soil threat	On-site effect	Off-site effect	Quantified impact (2003 prices)
	to assess the extent of contamination and the risk of further contamination of other environmental media (water, air) ** - Costs of exposure protection measures for workers operating on a contaminated industrial site - Costs due to land property depreciation if land use restrictions are applied thus representing a loss of economic value of the industrial asset	- Costs of treatment of surface water, groundwater or drinking water contaminated through the soil** - Costs for insurance companies - Costs of dredging and disposing of contaminated sediments downstream borne by water supply companies or public administrations - Costs for the depreciation of surrounding land** - Costs for increased food safety controls borne by public administrations to detect contaminated food	lower and the upper bound, show how difficult it is to quantify the costs due to soil contamination and show the disparity between test cases. In order to use a prudent estimate and to the inaccuracy of data, it was considered to be more sound to use the intermediate value of €17.3 billion per year all throughout the report.
Sealing	- Opportunity costs due to restrictions on land use	- Cost linked to runoff water from housing and traffic areas, which is normally unfiltered and potentially contaminated with harmful chemicals - Costs due to fragmentation of habitats and disruption of migration corridors for wildlife - Costs due to impacts on landscape and amenity values - Costs on biodiversity	No sufficient information to estimate the costs derived from sealing of soil.
Biodiversity	- Yield losses due to reduce soil fertility	- Costs linked to the loss of ecosystem functions and reduced capacity to sequester carbon - Costs related to impacts on landscape and amenity values - Costs related to changes in genetic resources	No sufficient information to estimate the costs derived from biodiversity loss.
TOTAL (quantified effects)			**The quantified effects amount to €7.7bn to €38.14bn pa.** **(Includes: partial costs of erosion, SOM, contamination and cost of one landslide event)** **While 7.7bn is the sum of the quantified minimum, 38.14bn is the sum of the maximum of the quantified effects, except for contamination for which the intermediate value was taken (since the uncertainty around the high value was considered too large for contamination compared to the other threats)**

Note: ** denotes impacts that have been quantified

Aggregating the individual effects that were able to be quantified in the 2006 Impact Assessment (IA) (noting that many impacts were not able to be quantified), a total estimate of the impacts of soil degradation of between EUR 7.7bn - 38bn per annum (in 2003 prices). The analysis in the 2006 IA is repeated in Montanarella (2007)[500] who also estimates a total cost of EUR 38bn pa. This aggregate figure has been used by other estimates of the costs of soil degradation, including the estimated impact of EUR 50bn per annum cited by the Mission board for Soil health and food[501] and referred to in the EU Soil Strategy 2030.[502]

That said, it is important to note that this assessment of impacts was only partial for a number of reasons:

- It presented the cost estimations for 5 land degradation processes – the costs of all degradation could not be quantitatively assessed.
- For those degradations where a quantitative estimate has been produced, not all effects were quantified (e.g., in particular several off-site effects could not be captured).
- For those impacts that were quantified, in many cases the estimation was partial – e.g. the estimate of erosion impacts only covered impacts in 13 countries and to five land use categories covering a surface area of 150 million ha; estimate of salinisation effects only covered three countries; for landslides, a proxy cost for a single event was included as it was not possible to link a proportionate of landslides or their effects that would be mitigated should soils be restored to a healthy state.

Estimation of costs of soil degradation in 2023

Estimating the costs of soil degradation is essential since it provides an estimate of the benefits that could be achieved if degradation was stopped and soil health restored. This study makes an updated estimation of the costs of soil degradation, using and updating the knowledge base of the 2006 IA with the relevant soil degradations, and expresses the costs in 2023 prices.

Since the 2006 IA, several studies have been published highlighting and reaffirming the wide range of benefits offered by soil restoration, and some offering updated monetisation of the costs of soil degradation, some of which could be used to update and expand the analysis from the 2006 IA.

With respect to ***erosion,*** based on costs for siltation and groundwater pollution, Kuhlman et al. (2010) estimate the EU-wide off-site (external) costs of soil degradation to be around EUR 1.8 billion every year. These off-site costs come in the form of a reduced frequency of flood events, for example. In 2021 alone, flooding events were calculated at causing €38 billion in economic losses.[503] The costs of flooding are quantified alongside other effects as part of off-site erosion in the 2006 IA, which in total are greater than Kuhlman's estimate, hence no adjustment is made to the off-site effects of erosion based on this study.

[500] https://link.springer.com/chapter/10.1007/978-3-540-72438-4_5
[501] https://op.europa.eu/en/publication-detail/-/publication/4ebd2586-fc85-11ea-b44f-01aa75ed71a1/
[502] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021SC0323&from=EN
[503] AON (2022) 2021 Weather, Climate and Catastrophe Insight. US $46billion calculated as €37.59 billion.

Another off-site benefit addressed by the 2006 IA is that of sediment removal. The JRC[504] has done a meta-analysis collecting information from local studies (Italy, Luxembourg, Germany, France, and Netherlands) on sediments removal costs and the average price is 15-20 Euros per m3 and 5-10 Euros per m3 for transfer the sediments elsewhere. Therefore, a grosso-modo estimation of removing the 75 million m3 is about 1.5 – 2.3 billion Euros per year (2018 prices). Those estimates are done using the method of dry excavation and removal to landfill. Again, as for flooding, the 2006 IA off-site impacts of erosion quantify the impact of sediment removal, treatment and disposal alongside other off-site costs of erosion, which in total are higher than the estimates of the JRC. Hence it is not possible to use this updated JRC figure to revise the benefits.

Reducing or preventing erosion through SSM measures can also lead to on-site effects, in particular long-term increase and maintenance in soil productivity and an increase in yield in the longer term. For example, an increase in yields between 5% in Iceland and 13% in the case of Cyprus was observed. The RECARE 2018 Impact Assessment, it was stated that some of the highest costs are caused by soil erosion and a large proportion of these costs are off-site costs, in the area of 720m to 14bn EUR annually (2003 prices),[505] re-iterating the quantified assessment from the 2006 IA. These yield loss estimates are also affirmed by a study by IEEP[506] who report that soil degradation is having a negative impact on food production, with erosion alone already causing losses of almost 3 million tonnes of wheat and 0.6 million tonnes of maize per year in the EU. At current wheat and maize prices, this produces a total estimated effect in the same order of magnitude of other studies assessing this effect. This study was not used to adjust the degradation cost estimates.

A study by Panagos et al. (2018)[507] reported that the 12 million hectares of agricultural areas in the EU that suffer from severe erosion are estimated to lose around 0.43% of their crop productivity annually. The annual cost of this loss in agricultural productivity is estimated at around €1.25 billion (2016 prices). Italy emerges as the country that suffers the highest economic impact, whereas the agricultural sector in most Northern and Central European countries is only marginally affected by soil erosion losses. This figure was also reported and applied in the Nature Restoration Law Impact Assessment. The more recent figures in this study are not used for the updated estimate, given the lower bound and long-term effect estimates from the 2006 IA present a clearer representation of the possible range of effects.

A subsequent study by Panagos et al., (2022)[508] estimated that current phosphorus displacement in the EU-27+UK due to erosion was around 374,000 tonnes, of which approximately 97,000 t ends up in river basins and sea outlets. The cost of DAP phosphate (the common application of phosphate to soils) has varied widely over time, in particular over the past two years: adopting a low-high price range from EUR 308 to EUR 622 per tonne (average of 2013-20, and 2021-22 prices respectively), it is estimated that the cost of phosphate loss in agricultural soils due to (wind and water erosion) costs the EU-27+UK between EUR 575 m – 1.2bn annually (accounting for the total phosphate content of 1 tonne of DAP phosphate-approximately 20%). The overlap between these estimates for the replacement cost of P, and the crop productivity loss estimates is unclear – i.e. it is unclear whether if

[504] Borrelli, P., Van Oost, K., Meusburger, K., Alewell, C., Lugato, E. and Panagos, P., 2018. A step towards a holistic assessment of soil degradation in Europe: Coupling on-site erosion with sediment transfer and carbon fluxes. Environmental Research, 161: 291-298. https://www.sciencedirect.com/science/article/pii/S0013935117308137
[505] (PDF) Integrated impact assessment of European soil protection policies (researchgate.net)
[506] https://ieep.eu/publications/environmental-degradation-impacts-on-agricultural-production
[507] Panagos, P., Standardi, G., Borrelli, P., Lugato, E., Montanarella, L. and Bosello, F., 2018. Cost of agricultural productivity loss due to soil erosion in the European Union: From direct cost evaluation approaches to the use of macroeconomic models. Land Degradation & Development, 29(3): 471-484.
https://onlinelibrary.wiley.com/doi/full/10.1002/ldr.2879
[508] Panagos et al., (2022) Improving the phosphorus budget of European agricultural soils

the P lost is replaced, whether this would offset the full or only part of the yield reduction effect. Given this risk the P=loss estimates are not used in the updated assessment.

Separately, a recent report by WUR (2021)[509] on soil degradation and the true price of agri-food products highlights three indicators of soil degradation: soil erosion (wind and water), SOC loss and soil compaction. Here, the focus was especially on the on-site components of soil erosion which include: loss of nutrients, reduced harvests and reduced value of land and the off-site components of soil erosion which include: silting up of waterways, flooding and repairing public and private property. Taking all these factors into account, that study set the estimated global value of soil erosion from water was at 0.0214 €/kg soil loss and the estimated global value of soil erosion from wind was set at 0.0273 €/kg soil loss. Combining these damage costs with the estimated rates of erosion of EU soils made by the EEA and JRC (see section 1.6.3 below), this produces a total estimate of the cost of erosion (including on-site and off-site effects) of around EUR 7.3bn (2020 prices). These estimates are smaller than those based on the adjusted 2006 IA results, and hence are not used in the updated analysis.

For ***compaction,*** it is estimated that the onsite benefits of SSM practices that prevent compaction are around €1 billion per year for EU-25.[510] Reducing or preventing compaction through SSM measures can lead to a long term increase in output, generating income for primary producers[511]. Otherwise, another study showed that heavy agricultural equipment deployed in wet conditions can reduce long-term crop yields by 2.5-15%,[512] and Graves et al. (2015)[513] estimated the total annual cost of soil compaction in England and Wales to €540 million per annum (pa) (currency rate January 2019). Hence, per hectare costs of soil compaction amount to approximately €140.2/ha/pa when related to the compaction-affected area, and about €56.4 ha/pa on the basis of the total agricultural area[514]. Combining this with the estimated area of EU agricultural soils that suffer from compaction of 23%,[515] this produces an estimated cost of compaction from reduced yield of around EUR 5.8bn pa. Applying the range of change in crop yield from Graves et al. directly to the total EU agricultural output suggests an impact range of EUR 1.5bn to 9.2bn pa (2023 prices) – this range is used in the updated estimates of cost of soil degradation in this study.

Reducing or preventing the ***loss of SOM*** through SSM measures can lead to an increase in the production costs for farmers in the short to medium term but reduced costs in the longer term, due to higher soil productivity. This also depends on the measure, with some having much higher short to medium term production costs than others.[516] Reducing loss of SOM can also lead to improved soil productivity – an increase in yields of between 1 and 9% in terms of mineral soils, and between 4-20% in terms of organic soils.[517] Combining SOM SMPs – e.g., combining rewetting with agricultural or forestry use (paludiculture) – can lead to higher yields of up to 20%.[518]

509 https://edepot.wur.nl/557712
510 EUR-Lex - 52006SC1165 - EN - EUR-Lex (europa.eu)
511 *Ibid.*
512 Voorhees (2000) Long-term effect of subsoil compaction on yield of maize. In: Horn et al., (Eds.), Subsoil Compaction: Distribution, Processes and Consequences; Bennetzen (2016) Soil compaction effects on crop yield (in Danish). In Pedersen, J.B. (Ed.), Oversigt over Landsforsøgene 2016. Report from The Danish Agriculture & Food Council; Brus and van den Akker (2017) How serious a problem is subsoil compaction in the Netherlands? A survey based on probability sampling; Stolte et al., (2016) Soil threats in Europe- Available at: https://esdac.jrc.ec.europa.eu/public_path/shared_folder/doc_pub/EUR27607.pdf
513 The total costs of soil degradation in England and Wales - ScienceDirect
514 EEA (2022): Soil monitoring in Europe: indicators and thresholds for soil quality assessment. https://www.eea.europa.eu/publications/soil-monitoring-in-europe-indicators-and-thresholds
515 Driver-Pressure-State-Impact-Response (DPSIR) Analysis and Risk Assessment for Soil Compaction—A European Perspective - ScienceDirect
516 *Ibid.Reduced stocking density*
517 (PDF) Integrated impact assessment of European soil protection policies (researchgate.net)
518 (PDF) Integrated impact assessment of European soil protection policies (researchgate.net)

Studies have also considered the impact of soils on carbon. The EU Soil Strategy 2030 notes that carbon sequestration in mineral soils, while depending on soil type and climatic conditions, is a cost-effective emission mitigation method with significant potential to sequester between 11 to 38 MtCO2eq annually in Europe. Hence applying the short and long-term costs of carbon from DG MOVE's external costs of transport,[519] an updated estimate of the costs of lost sequestration could be EUR 4.4bn under a central short-term carbon price, and as high as EUR 12.0bn pa (using central, long-run carbon price), or even EUR 22.2 bn pa (using the high long-run carbon price, all 2023 prices). The low and high long-term carbon prices were used to update the off-site benefits of avoiding SOM loss as part of this study.

By contrast, a publication by Lugato et al. (2018)[520] places the estimate of loss of carbon due to soil erosion at a much lower figure of EUR 150m – 300m pa (2018 prices). This study takes soil organic carbon loss due to soil erosion is estimated to about 1.8-2.2 Million tonnes per year, equivalent to the 6.6 – 8.1 CO2 equivalent, and applies the much lower market price of an average 20-40 Euros per tCO_2 to value these emissions. A separate study by De Rosa (unpublished further assesses loss of Carbon in arable lands (due to land use change) and estimates its value to be around EUR 425-850 million per year. The study explores that changes in land cover and certain land use practices may lead to carbon losses. For example, deforestation, the conversion of grassland to cropland, draining peatlands, and intensive agriculture have been shown to lower the organic carbon content of soils. The results have been used to model, at spatial scale, changes in soil organic carbon stocks for agricultural grasslands and croplands between 2009 and 2018 (LUCAS campaigns). Organic carbon stocks in the EU's agricultural soils fell 0.6 % between 2009 and 2018 which means a loss of 52 Mt of carbon (eq. to 190 Mt CO2). Taking as a market price an average 20-40 Euros per tCO_2, it is concluded that the total cost of carbon loss is 3.8 – 7.2 billion in 9 years (LUCAS periods), equating to a loss of EUR 425 – 850 million per year. Given these studies apply a much lower carbon price, different to those in EU appraisal guidance, these estimates are not applied in the updated estimates in this study.

One pressure not captured by the 2006 IA is through ***drought***, and the role soil can play in alleviating its effects. The JRC[521] have investigated the impacts of climate change on droughts. They report that healthy soils can release water at a slower rate during drought conditions- mitigating the impacts felt to economic activities including agriculture, energy and water sectors. Such activities incur approximately €9 billion economic losses per year in the EU-27+UK due to droughts (2020 prices). Depending on the region, between 39-60% of the losses relate to agriculture and 22-48% to the energy sector. Public water supply accounts for between 9-20% of the total damage. It is not possible to assess with certainty the level of damage avoided were all soils in the EU in a healthy condition, but soil will have an important role to play. For illustration, assuming that all losses in agriculture could be resolved through improved soil health and greater water retention, good soil health may achieve an additional benefits of at least EUR 3.9bn pa (2023 prices). There is low risk of overlap between these effects and those assessed elsewhere (e.g. impacts of erosion, which focus on loss of nutrients, available planting area, etc, and not explicitly on water loss), as such these estimates have been added as part of the updated estimate of degradation cost.

[519] https://op.europa.eu/en/publication-detail/-/publication/9781f65f-8448-11ea-bf12-01aa75ed71a1
[520] Lugato, E., Smith, P., Borrelli, P., Panagos, P., Ballabio, C., Orgiazzi, A., Fernandez-Ugalde, O., Montanarella, L. and Jones, A., 2018. Soil erosion is unlikely to drive a future carbon sink in Europe. Science Advances, 4(11), p.eaau3523.
[521] https://joint-research-centre.ec.europa.eu/system/files/2020-09/07_pesetaiv_droughts_sc_august2020_en.pdf

Reducing or preventing ***salinisation or acidification*** through SSM measures can lead to: long-term increase in yield, increasing income; and increased investments in better irrigation techniques and equipment. In the short term, nevertheless such investments may take place in any case with the aim of achieving a more sustainable use of water.[522] Increases in yield can reach up to 73% depending on the location, soil type, and practices being implemented. However, there is no sufficient data on which to base a comprehensive assessment for inclusion in the updated estimate of degradation costs in this study.

A study by the JRC (2009)[523] also explored the effects of salinisation. The main objective of the PESETA (Projection of Economic impacts of climate change in Sectors of the European Union based on boTtom-up Analysis) project was to contribute to a better understanding of the possible physical and economic effects induced by climate change in Europe over the 21st century. The project combined high resolution climate and sectoral impact models with comprehensive economic models, able to provide estimates of the impacts for alternative climate futures. The estimated salinity intrusion costs across the scenarios ranged from an annual impact of EUR 575 m to EUR 616.5m (2009 prices) – updating to 2023 prices and excluding the UK, this presents an annual impact of EUR 917m to EUR 983m. These figures are used to update the estimated cost of salinisation in the updated analysis.

The loss of **soil biodiversity** has been identified as contributing to reduced crop yields. Rich, diverse soil communities can lead to increased storing capacity of soil organic matter- which in turn can increase soil organic carbon and ultimately increase crop yields.[524] Studies have shown that more than 75% of crops and 35% of food produced rely on pollination services,[525] which are provided not only by the likes of bees, but also pollinators which directly interact with soil such as beetles (*Carpophilus hemipterus L.* and *Carpophilus mutilates*) and thrips (*Thrips hawaiiensis* and *Haplothrips tenuipennis*).[526] Furthermore, the presence of earthworms has been reported, on average, to increase crop yields in 25% of agroecosystems,[527] underlying their importance in sustaining economically viable crop yields. Some studies have advanced methods and approaches to quantify and monetise ***biodiversity effects.*** For example, Pascual et al. (2015)[528] and Brady et al.[529] highlight the wide range of benefits offered by soil diversity and develop frameworks for their assessment, but no study has yet deployed these to monetise soil biodiversity benefits at EU-level. Another study by Getzner et al. (2017)[530] demonstrate that such natural capital approaches offer a potential framework through which to produce monetary estimates, but also highlight that many of the 'protective functions' of soils will already be captured in other cost estimates (i.e. those assessed for other individual soil threats explored above). Furthermore, a review of previous works aimed at providing values for ecosystem services to explore the cost-benefit trade off of avoiding fire damage in forests undertaken by the JRC (unpublished) concludes that updating the figures reported in de Groot et al. (2012)[531] to 2022 values and euros, the monetary units of the ecosystem services

522 *Ibid.*
523 https://publications.jrc.ec.europa.eu/repository/bitstream/JRC55390/jrc55390.pdf
524 Bach et al., (2020) Soil Biodiversity Integrates Solutions for a Sustainable Future
525 Apriyani et al., (2021) What evidence exists on the relationship between agricultural production and biodiversity in tropical rainforest areas? A systematic map protocol
526 Klein et al., (2006) Importance of pollinators in changing landscapes for world crops
527 Nielsen, Wall and Six (2015) Soil biodiversity and the environment
528 https://www.sciencedirect.com/science/article/pii/S2212041615300115?via%3Dihub
529 https://acsess.onlinelibrary.wiley.com/doi/10.2134/agronj14.0597
530 Gravitational natural hazards: Valuing the protective function of Alpine forests - ScienceDirect
531 De Groot R, Brander L, van der Ploeg S, Costanza R, Bernard F, Braat L, Christie M, Crossman N, Ghermandi A, Hein L, Hussain S, Kumar P, McVittie A, Portela R, Rodriguez LC, ten Brink P, van Beukering P. Global estimates of the value of ecosystems and their services in monetary units. Ecosyst Serv. 2012; https://doi.org/10.1016/j.ecoser.2012.07.005

provided by forests would be of 3875 ± 6992 €/ha/yr, 2042 ± 408 €/ha/yr for woodlands, and 5487 ± 3563 €/ha/yr for freshwater bodies. It could be assumed that the loss of 1 tonne of soil could already endanger soil functions and water quality and therefore, the provision of many of those ecosystem services. That said, it has not been possible to produce a quantitative estimate of impacts on biodiversity as data is not readily available on the soil loss in forests and woodlands, and there is no quantitative estimate of how 'many' services would be lost.

For ***soil sealing***, no one study has produced a comprehensive estimate of the impacts of soil sealing. The average absolute EU-27 area of soil sealed between 2006-2015 was approximately 332 km^2 per year, reaching a cumulative area of 2,989 km (or around 1.65% of the total EU land area)[532]. By contrast, the latest JRC estimate suggests that a cumulative area of 1.45% is sealed. That said, a larger area of land succumbed to land take over this period: Between 2000 and 2018, the EU-28 lost of 394.34 km^2/yr of arable lands and permanent crops and 212.44 km^2/yr of pastures and mosaic farmlands on average each year, leading to a cumulative 174,792 of artificial land coverage in the EU27 in 2018.[533] Although the value of land lost will vary widely depending on the type of soil and ecosystem services provided, some studies have sought to estimate the ecosystem values of land: e.g. the SOS4LIFE project in Italy under LIFE estimated the loss of ecosystem services per Ha of land take to be EUR 309.60 pa. A separate study (Vysna et al., 2021)[534] placed the value of remediated soil at 380 EUR/hectare/year based on its provided ecosystem services. These values could be up to ten times more where, for example, the land lost is woodland (as illustrated in the paragraph above). Combining the low and high range of land affected (low is area of land sealed estimate by the JRC, high is area of artificial land coverage) and value of ecosystem services (low from SOS4LIFE, high from Vysna et al.) provides an estimated value of ecosystem services lost to soil sealing and land take of between EUR 1.9bn to 6.6bn pa. This estimate is included in the updated estimate of soil degradation costs made in this study.

That said, simply assessing the ecosystem service impacts risks overlooking (and hence undercosting) other detrimental affects associated with soil sealing. For example, soil sealing makes previously permeable, water retaining surfaces, impermeable- preventing water to infiltrate the soil substrate and increasing the proportion of rapid surface runoff which accrues downstream. Studies have identified that the impact of the last 30 years of soil sealing in the EU have increased flood risk to the same effect as moderate climate change scenarios (i.e. the RCP 4.5 scenario). Ultimately, it is estimated that the continued rate of urban development and soil sealing could lead to an increase in areas at higher risks of flooding corresponding to 1-2% of total urban areas (when coupled with projected climate change scenarios). In 2021 alone, flooding events were calculated at causing €38 billion in economic losses.[535]

In the most extreme case, where soil is substantially degraded, there are then a range of costs to businesses, wider society, and public authorities resulting from the abandonment of land. Farmland abandonment can be defined as the cessation of agricultural activities on a given surface of land, often giving way to natural succession of land. This can feed into public authority costs. Overall, implementing various SSM practices can lead to a short term yield improvements on agricultural land specifically, as well as the long-term avoidance of having to abandon land, and the consequent

532 EEA (2022) What is soil sealing and why is it important to monitor it? Available at: https://www.eea.europa.eu/help/faq/what-is-soil-sealing-and
533 EUROSTAT (2021) Land covered by artificial surfaces by NUTS 2 regions
534 https://www.researchgate.net/publication/352707626_Accounting_for_ecosystems_and_their_services_in_the_European_Union_INCA_-_2021_edition
535 AON (2022) 2021 Weather, Climate and Catastrophe Insight. US $46billion calculated as €37.59 billion

loss of production, economic value of the land, and related unemployment[536], which are issues faced in agricultural, forested, and urban areas.

Further evidence supporting the benefits of implementing SSM measures is highlighted by a report by the ELD initiative,[537] which concluded: *Contributing experts have researched and analysed a variety of case studies and examples across scales, and it has been consistently shown that investing in sustainable land management can be economically rewarding with benefits outweighing costs severalfold in most cases.* The study also undertook scenario analysis of different development pathways, and estimated that sustainable land management enabling environments could generate a global additional benefit of USD 75.6 trillion annually. In addition, the study set out estimates of regional ecosystem service value losses from land degradation based on Haberl and Imhoff models – the per person and per sq km estimates presented in the report are shown in the table below, alongside an implied total impact for Europe.

Table 4-8: Regional ecosystem service value losses per annum from land degradation (all 2015 prices)

Region	***Estimate method***	**Value per person (USD 2015 prices)**	**Value per sq km (USD 2015 prices)**	***Implied total value (based on value per person – EUR 2015 prices)***	***Implied total value (based value on per km – EUR 2015 prices)***
Europe	*Haberl*	2,211	72,206	*EUR 929bn pa*	*EUR 287bn pa*
	Imhoff	2,570	83,934	*EUR 1,079bn pa*	*EUR 334bn pa*
Eastern Europe	*Haberl*	4,500	71,050	*Not estimated*	*Not estimated*
	Imhoff	3,085	48,719		
Northern Europe	*Haberl*	1,763	102,393		
	Imhoff	5,305	308,156		
Southern Europe	*Haberl*	766	90,862		
	Imhoff	1,356	160,916		
Western Europe	*Haberl*	120	21,087		
	Imhoff	1,306	229,989		

Bringing the above evidence base together ***in summary*** the outputs of these more recent studies can be used to review and update some of the impacts assessed in the 2006 IA. A revision of these calculations is presented in the following table. These revisions suggest that the combined costs of soil degradation that can be quantified, which were assessed as EUR 38bn per annum (2003 prices), could be increased to an estimate of EUR 74bn pa (2023 prices - see table below) – this reflects the most recent estimations of costs of specific soil degradations. These estimates represent a benefit achieved each year where these soil threats are removed – i.e. this represents an estimation of the benefits that would be captured once all soils have achieved good health status (i.e. in 2050 and beyond).

The quantification of costs is partial as:

- The impacts of soil biodiversity loss could not be quantified
- For those pressures where a quantitative estimate has been produced, not all effects associated with the threat were quantified (only some impacts were quantified) . For example, many of the 'off-site' effects associated with the soil threats could not be quantified.

[536] SWD accompanying the Thematic Strategy for Soil Protection Microsoft Word - EN_SEC_620.doc (europa.eu)
[537] https://www.eld-initiative.org/fileadmin/ELD_Filter_Tool/Publication_The_Value_of_Land__Reviewed_/ELD-main-report_en_10_web_72dpi.pdf

- For those impacts that were quantified, in many cases the estimation itself was partial, for example:
  - the estimate of erosion impacts only covers impacts in 13 countries and to five land use categories covering a surface area of 150 million ha – insufficient detail on the original methodology adopted prevented the further extrapolation of these effects to the full EU-27;
  - The 2006 IA estimates were made on the basis of EU-25 (including the UK). For this study, the scope of impacts would instead be the EU-27 (excluding the UK), although it was not possible to make an adjustment for this in the quantitative estimates.
- For some impacts that were quantified, a 'conservative' estimate of the high-bound of impacts is taken, but a true high bound may be even higher. For example:
  - High bound estimate for off-site contamination costs actually adopts the central estimate of effects from the range estimated in the 2006 IA – the high bound estimate would increase off-site impacts from EUR 24.1bn to EUR 292bn in 2023 prices. The 2006 IA suggested that: *These estimates, and in particular the big difference between the lower and the upper bound, show how difficult it is to quantify the costs due to soil contamination and show the disparity between test cases. In order to use a prudent estimate and to the inaccuracy of data, it was considered to be more sound to use the intermediate value of €17.3 billion per year all through out the report.*

Table 4-9: Revised estimates of cost of soil degradation in Europe

Soil threat	2006 IA / Montanarella (2007) estimate (2003 prices)	Revised 2023 estimate (2023 prices)	Impacts quantified	Notes on adjustment
Erosion	EUR 0.7bn pa – 14.0bn pa	EUR 2.4 bn pa – 23.1bn pa	On-site: Yield losses due to eroded fertile land*** Off-site: Costs of sediment removal, treatment and disposal - Costs due to infrastructure (roads, dams and water supply) and property damage caused by sediments run off and flooding - Costs due to necessary treatment of water (surface, groundwater) - Costs due to damage to recreational functions Long term effects of erosion have been included in the upper value	Off-site costs same as 2006 IA (only price base updated). On-site yield impact updated based on long-term effects estimated by 2006 IA, updated to 2023 prices
Decline of soil organic matter (SOM)	EUR 3.4bn pa – 5.6bn pa	EUR 9.8bn – 25.0bn pa	On-site: Yield losses due to reduced soil fertility Off-site: Costs related to an increased release of greenhouse gases from soil*** Long term carbon prices have been included	On-site costs same as 2006 IA (only price base updated). Estimated soil carbon sequestration benefits updated based on mitigation estimate from Soil Strategy and DG MOVE long run carbon prices
Compaction	Not estimated	EUR 1.5bn – 9.2bn pa	On-site: Yield losses due to compacted soils***	Estimate based on Graves et al. damage per hectare and yield loss from Voorhees et al.
Landslides	EUR 1.2bn per event	Out of scope	NA	NA
Contamination	EUR 2.4bn – 17.3bn pa	EUR 3.4bn – 292.4bn pa****	On-site: Costs of monitoring measures and impact assessment studies that must be carried out in order to assess the extent of contamination and the risk of further contamination of other environmental media (water, air) Off-site: Costs of increased health care needs for people affected by contamination, which include the treatment of patients and the monitoring of their health during long periods to detect the effects of exposure to soil contamination - Costs of treatment of surface water, groundwater or drinking water contaminated through the soil	No change (only price base updated)
Salinisation	EUR 0.2bn – 0.3bn pa	EUR 0.9bn – 1.0bn pa	On-site: Yield losses due to reduced soil fertility*** Off-site: Costs due to damage to transport infrastructure (roads and bridges) from shallow saline groundwater - Costs due to damage to water supply infrastructure - Environmental costs, including impacts on native vegetation, riparian ecosystems and wetlands	Updated estimate based on JRC (2009)
Sealing	Not estimated	EUR 1.9bn – 6.6bn pa	On-site: Loss of ecosystem services***	New estimation based on value of lost ecosystem services and cumulative area lost to land-take and soil sealing
Biodiversity	Not estimated	Not estimated	n/a	No change

Soil threat	2006 IA / Montanarella (2007) estimate (2003 prices)	Revised 2023 estimate (2023 prices)	Impacts quantified	Notes on adjustment
Drought	Not estimated	EUR 0 - 3.9bn pa	On-site: mitigated economic losses in agricultural sector***	Illustrative estimate based on climate change impact on droughts and consequent economic loss for agriculture
Total quantified effects	**EUR 7.7bn to 38.1bn***	**EUR 19.8bn to 361.3bn*,****	**All above quantified effects (does not capture range of quantified effects)**	**As above rows**
Total quantified effects (Excluding contamination)	***EUR 5.3bn to 20.8bn***	***EUR 16.5bn to 68.8bn***	***All above quantified effects, excluding contamination (does not capture range of quantified effects)***	***As above rows***

Notes: * captures erosion, SOM, contamination and cost of one landslide event (salinisation not included); ** also captures new cost estimates for drought (high bound only), sealing, salinisation and compaction, but excludes landslides; ***New impacts quantified for revised estimate; ****High bound estimate for off-site contamination costs in 2006 IA adopted the central estimate of effects from the range estimated. The 2006 IA suggested that: *These estimates, and in particular the big difference between the lower and the upper bound, show how difficult it is to quantify the costs due to soil contamination and show the disparity between test cases. In order to use a prudent estimate and to the inaccuracy of data, it was considered to be more sound to use the intermediate value of €17.3 billion per year (2003 prices) all through out the report.* For the revised 2023 estimate, high bound adopts the high bound estimate from the 2006 IA, after updating the price base. The intermediate estimate from the 2006 IA updated to 2023 prices is EUR 24.4bn pa.

The table below shows the split of impacts between on-site and off-site effects for the revised estimates. The on-site impacts focus on yield impacts of soil threats. An estimate of yield impacts has also been made through the illustrative analysis of the impacts of a sample of 5 SSM measures – see next section. Rather than building up the impacts by soil threat, this instead considers the impacts of SSM measures (which could be implemented to resolve such soil threats).

By comparison, the combined impact of the yield impacts of the 5 illustrative SSM measures ranges from 17.9bn to 27.5bn EUR pa (2020 prices), not too dissimilar to the impacts estimated through considering soil threats. As noted in the illustrative analysis, this assesses the impacts of 5 potential SSM measures implemented at EU-level, but the impact on soil health indicators of these measures could not be assessed hence it is uncertain to what extent these measures work towards, achieve or potentially over achieve against the indicators and threats. As such, when considering the aggregate benefits of measures taken to restore soils to good health, the estimation via soil threats is considered a more relevant estimate.

Table 4-10: Revised estimates of cost of soil degradation in Europe, split on-site and off-site (per annum)

Soil threat	Revised estimated – on-site (2023 prices)	Revised estimated – off-site (2023 prices)
Erosion	EUR 1.4bn – 4.6bn	EUR 1.0bn – 18.5bn
Decline of soil organic matter (SOM)	EUR 2.8bn	EUR 7.0bn – 22.2bn
Compaction	EUR 1.5bn – 9.2bn	Not estimated
Salinisation	EUR 0.9bn – 1.0bn	Not estimated
Contamination	EUR 0.1bn – 0.3bn	EUR 3.2bn – 292.1bn
Sealing	Not estimated	EUR 1.9bn – 6.6bn
Biodiversity	Not estimated	Not estimated
Drought	EUR 0 – 3.9bn	Not estimated
Total (quantified effects)	**EUR 6.8bn – 21.9bn**	**EUR 13.0bn - 339.4bn**

Illustrative estimates of total economic costs and benefits for specific SSM practices

Additional research and analysis has been undertaken under this study to explore the economic costs and benefits of SSM practices, in particular were deployed at EU-level. Given the state of the underlying evidence base, the analysis does not look specifically at a single Option or Options under these building blocks but serves to illustrate the order of magnitude of effects that could be expected if the SSM practices were implemented as a consequence of any of the Options under these building blocks.

A wide range of SSM practices exist that are applicable to different climates, soil types and land-uses. Again, given limitations in the underlying evidence base and lack of a single model with which the impacts of multiple SSM practices can be modelled simultaneously, for this study a sample of SSM practices have been selected to subject to quantitative analysis to illustrate the potential costs and economic benefits associated with such measures.

The summary results of this analysis are presented in the following table. Further detail on the data sources and methodology used are presented in section 7. The results of this analysis should be interpreted as illustrative only as a number of stretching assumptions have been made, in particular in the extrapolation of the impacts EU-wide. Furthermore, this analysis does not quantify the environmental and social impacts associated with these measures, and in some cases also omits important economic impacts.

These limitations aside, several insights can be drawn from the analysis:

- The trade-off of economic costs and benefits will vary significantly by practice-type (indeed this trade off will vary significantly for each individual practice depending on the conditions and location in which is implemented)
- When scaling up to EU-wide, although several simplifying assumptions have been made in this extrapolation, the cost of measures very quickly rises to significant levels – i.e. in the billions of euros per year. Hence under the options, where multiple practices are taken up, the costs will be significant. However, this does not take into account that many SSM practices will be taken up in the baseline, influenced by other legislations (e.g. CAP GAECs)
- Although the costs scale significantly to EU-level, for many practices there will be an economic benefit, and the scaling of these benefits would also increase dramatically to EU-level. Indeed for some measures, the benefits might more or less offset the costs (e.g. reduced tillage) whereas for others, the benefits may actually be greater than the costs (e.g. cover crops, crop rotation), and as such will deliver a net economic benefit. This will work towards offsetting the net costs of other measures under the package of SSM practices, even before the environmental and social benefits are considered against the costs. To note, although many SSM practices could deliver a net economic benefits they often do not occur already in practice. This may be due to a number of barriers in practice, including that many incur a high initial CAPEX, whereas the benefits are typically seen in the long term with net losses in the short term; this creates a barrier to many economically beneficial SSM practices being implemented already.

Table 4-11: Illustrative, order of magnitude, estimates of the costs and benefits of deploying selected SSM practices on an EU-wide basis (2020 prices)

SSM practice	Economic costs	Economic benefits
Cover crops (applied to arable land growing cereals with bare soil over winter)	-2.8 bn EUR pa	9.3 to 9.5 bn EUR pa
Reduced tillage (applied to arable land using conventional tillage)	-13 bn EUR pa	6 to 12bn EUR pa
Crop rotation (applied to barley production)	-0.12 bn EUR pa	0.6 bn EUR pa
Use of organic manures	-1.5 bn to – 10.5 bn EUR pa	1.4 bn to 2.7 bn EUR pa
Reduction in stocking density	-8.1 bn EUR pa	0.6 to 2.7 bn pa

The 2006 IA also undertook analysis of the costs of measures taken to act upon soil degradation. A summary of the analysis and conclusions are presented in the following Box.

Information Box – analysis of costs of measures to act on soil degradation from the 2006 IA

The 2006 IA assessed a proposed Directive which would require Member States act upon the soil degradation processes identified by taking specific measures. Similar to the Options being considered for the present SHL, the precise choice of measures would have been left to Member States. The 2006 IA therefore highlighted that the package of potential measures will greatly differ for each Member State or region and so will their impacts, costs, benefits and cumulated effects. Therefore, any meaningful impact assessment of the implementation of the proposed course of action – i.e. implementation of Programmes of measures and National remediation Strategies – can only be undertaken at national or regional level. As such the 2006 IA predominantly relied on a qualitative assessment of impacts, although a quantitative assessment was undertaken based on different illustrative scenarios – although the 2006 IA caveats that: *Due to their highly speculative nature, the* *scenario-generated figures are under no circumstances to be looked at as the real implementation costs of the Soil Framework Directive.*

The 2006 IA defined a scenario illustrating possible implementation of the Programmes of measures against erosion, organic matter decline, salinisation, compaction and landslides. To quantify the effects, a scenario established packages of concrete measures to address these threats. Each practice was then weighted within its package according to the likely area to be covered by the specific practice (e.g. terracing would be necessary only in X% of the area at risk of erosion, so the costs for terracing would be multiplied by that factor). The costs of the weighted practices were added up per measure and multiplied by the area (in hectares) where such practices seem necessary. In order to calculate on how many hectares of EU 25 the different erosion packages should be applied, a GIS analysis was carried out comparing land under agriculture with lands at varying classes of erosion risk according to the PESERA model (although noting that the area at risk to be covered by the packages was smaller in some cases than the total EU area at risk). The measures and total estimated costs against each threat are summarised in the following table.

In total, the combined cost per annum across the 4 agriculture threats, and forestry and construction practices, the total costs came to EUR 14.4bn pa (2003 prices).

Table 4-12: Summary of threats, measures and costs from the 2006 IA scenarios

Threat	Measures (cost per ha pa, 2003 prices, unless specified)	Total area at risk to be covered by packages (m ha)	Total cost pa (EUR m, 2003 prices)
Erosion	***Serious erosion (>10 t/ha/yr)*** Conversion of arable to pasture (EUR 293) Terracing (construction) (EUR 849) Terracing (maintenance) (EUR 200) Buffer strips (EUR 227) Residue management (EUR 44) Conservation tillage (EUR 59) Cover crop (EUR 57) ***Moderate to serious erosion (2-10 t/ha/yr)*** Residue management (EUR 44) Conservation tillage (EUR 59) Cover crop (EUR 57)	Farming: serious erosion (>10 t/ha/y): 8.1 Farming: moderate to serious erosion (2-10 t/ha/y): 22.7	Farming: serious erosion (>10 t/ha/y): 2,400 Farming: moderate to serious erosion (2-10 t/ha/y): 3,200
Soil Organic Matter	Conservation tillage EUR 59) Cover crop (EUR 57) Application of Exogenous Organic Matter (EOM) (EUR 384)	Farming: SOM loss (soil organic carbon <2%): 30.5	3,600
Compaction	Low-impact machinery/ low-pressure tyres (EUR 9)	Farming: compaction: 40.4	200
Salinisation	Replacing surface or sprinkler irrigation by drip irrigation (EUR 604)	Farming: salinisation: 7.15	4,300
Forestry practices to combat soil threats	Reduced-impact logging (EUR 450)	Forestry (>0.5 t/ha/y erosion risk): 1.2	500
Construction practices to combat erosion	Erosion and sediment control on construction sites (USD for case study site in North Carolina = USD 64,617 total)	Construction (>2 t/ha/y erosion risk): 0.011	200
Total quantified costs			14,100

<u>Other economic impacts</u>

Implementing this option would also carry and ***administrative burden***. The EU's Evaluation of the impact of the CAP on habitats, landscapes, biodiversity[538] highlighted that CAP measures and SSM practices with the greatest benefits for biodiversity also have the greatest administrative cost. However, the study judged those costs to be proportionate to the expected biodiversity benefits, due to the inherent complexity of some of the management practices requiring support. Some Member States had increased administrative complexity for themselves by deciding to give farmers ecological focus areas (EFA) options under the former CAP. This means that they were already covered by then applicable cross-compliance standards for GAECs, plus any additional EFA options.

Through the implementation of Option 2, it will be up to the EC to produce an indicative annex that contains all SSM principles and practices harmful to soil health. An estimate of additional administrative burden places the upfront burden at around EUR 371,000 for the EC which includes an expert consultant study costing around EUR 250,000. For Member States, the administrative burden of the indicative annex is likely to be low considering the annex is not mandatory (0.1 FTE or EUR 135,000). Total upfront administrative burden could be around EUR 371,000 for Member States and 135,000 for the EC. Table below provides a comparison of administrative burden across the options.

Table 4-13: Total administrative burden across SSM options

Option number	EC – One-off costs	EC – Recurrent costs	MS – One-off costs	MS – Recurrent costs	Other – One-off costs	Other – Recurrent costs	TOTAL – one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 2	25,000	24,000	9,100	-	-	-	34,000	24,000

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

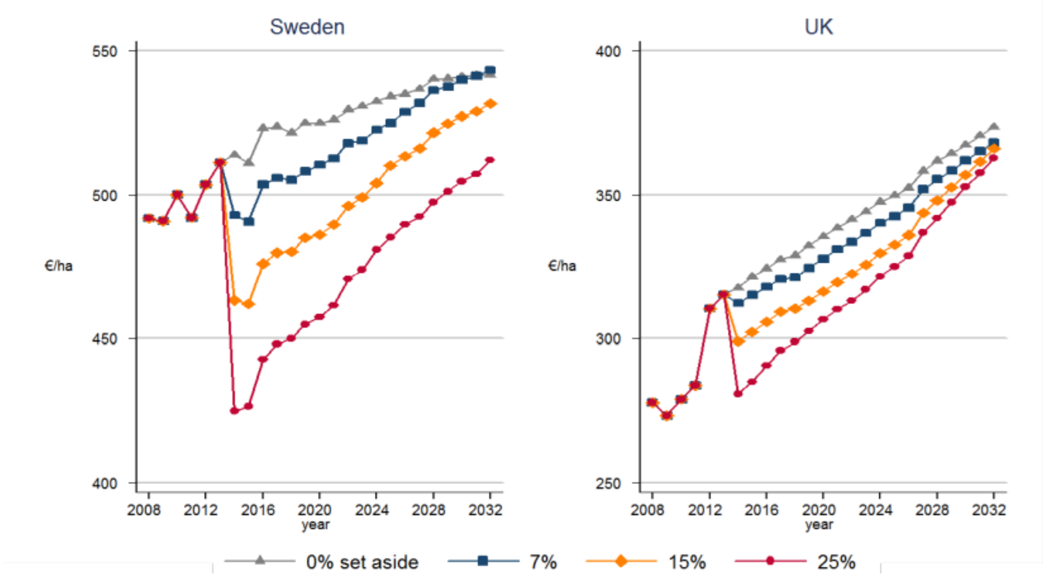
It is noted in the EU Soil Strategy that the banking and financial sector is increasingly interested in investing in those farmers who apply sustainable practices and increase soil carbon, as well as creating market-based incentives for storing carbon.[539] Investing in soil carbon will not only improve the sustainability of food production but also farmers' incomes (***sustainable development and food production)***. The figure below shows how farmers' maximum income, in arable areas in the UK and Sweden, will increase with soil through the creation of former ecological focus areas (EFAs) under the greening of the CAP until 2022. Not only do farmers benefit from higher yields but also from lower costs of inputs that are replaced by soil ecosystem services (i.e. improved fertility).[540] However, it should be noted that these returns occur far into the future (10-20 years), meaning in is costly in the short-term for farmers to adopt socially desirable conservation measures such as EFAs.

Under the CAP and the Habitat Directives, AECCs, Natura 2000 and non-productive investment measures and the forest-environment measures were found to deliver co-benefits with the objective of balanced territorial development as they can create opportunities for improving economies in rural areas through, for example, increased tourism or opportunities to market higher quality products.[541] A wide range of SSM practices positively impact a landscape. By protecting/improving soil structure, and planting cover crops and hedgerows, and setting aside land can also aid in reducing wind and water erosion, reducing flood risk, providing habitats for animal species, and improving the

[538] Microsoft Word - EN_SEC_620.doc (europa.eu)
[539] EU soil strategy for 2030 (europa.eu)
[540] Microsoft Word - Final publ report Nov2012.docx (agrifood.se) Microsoft Word - Final publ report Nov2012.docx (agrifood.se)
[541] Evaluation of the Common Agricultural Policy's impact on biodiversity (ieep.eu)

aesthetic value of the land.[542] This additional functionality may help growth of rural business and livelihoods in the surrounding areas beyond simply agriculture and forestry e.g. tourism, markets, infrastructure.[543]

Figure 4-2: Developments in project per hectare over time in Sweden (left) and the UK (right).



Economic – Option 2

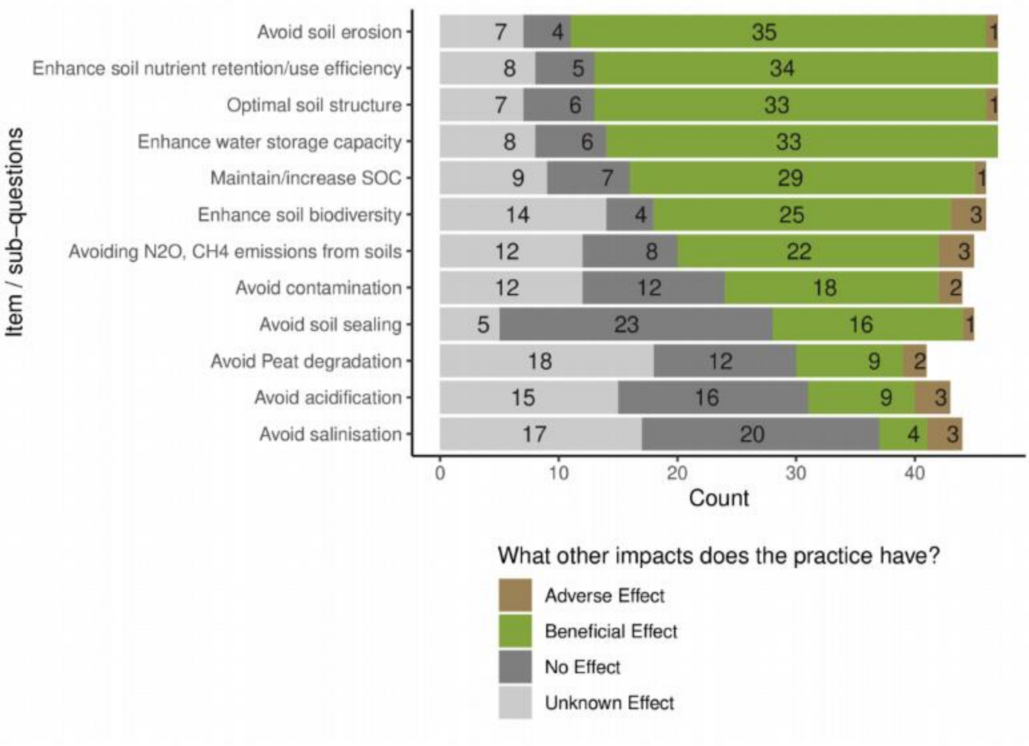
Under SSM2 no practices are mandated, which will mean that there is a variable increase in both the extent of practices being implemented (and therefore an increase in adjustment costs across the EU), and increases the economic benefits reaped from improving soil health, especially in comparison to SSM3 and SSM4 in this building block. In comparison to SSM3 and SSM4, the costs and benefits of this option (SSM2) were anticipated as being much smaller, given the greater flexibility for MS.

Environmental

The EJP's study on innovative soil management practices across Europe[544] assessed a wide range of 58 different SSM practices used in Europe across different agricultural, forestry, and urban and other land use systems. The figure below presents the potential impact of the practices taken into account in this study on pressures to soil (such erosion, compaction, salinisation, etc). It was noted that SSM practices currently in use in Europe mainly focus on soil erosion, nutrient use efficiency, soil structure, water storage capacity and have positive impact. The four less impacted issues are linked to soil sealing, peat, acidification and salinisation. Importantly, this suggests that URLMs are already going some way to implement SSM practices, which offers key data such as this, and provides a baseline within the EU for actions that aim to achieve soil health. Notably, there are a wide range of different measures that are associated with different threats to soil, and some practices are more applicable to a wider range of pressures and within a wider range of land use systems. It should also be noted that with most measures, there are instances where the measure has an adverse effect on soil; many SSM practices can be sustainable on one type of soil, but harmful on another

[542] 2022_SOIL_RISE_Foundation.pdf (risefoundation.eu)
[543] Best management practices for optimized use of soil and water in agriculture | DIGITAL.CSIC
[544] Innovative soil management practices across Europe (ejpsoil.eu)

Figure 4-3: Potential effect of the practices covered in the EJP's study on various soil pressures, such as erosion and compaction. The inventory of practices covered in the study can be found via the link below.



Source: EJP Soils

SSM practices can contribute to the preservation and improvement in the ***quality of natural resources***. A key benefit of SSM practices is of course improvements in soil. The size and type of benefit delivered will depend on the practice type, location and extent of implementation. For example:

- inclusion of different proportions (5%, 15%, and 25%) of grass in a typical arable crop rotation, which otherwise comprises only annual crops, can effectively rejuvenate soil ecosystem services in the region[545].
- Subsoiling/deep-tillage/inversion tillage is a practice that has the potential to restore soils with unhealthy structure/compaction by aerating it, increasing drainage, and breaking up soil aggregates. However, the principle of it is contrary to conservative agriculture and sustainable soil management, and thus may have some temporary negative impacts such as releasing carbon from soils.
- Expert stakeholders noted that the benefits of organic management on soil health are clear and well known. They commented that there is a need to further incentivise organic management, which can be done through the list of SSM practices under this building block.

SSM practices can also deliver improvements to ***air and water quality.*** For example, cover crops, alongside the key impact of avoiding soil erosion, offers the benefit of mopping up excess nutrients (N, of particular importance), thus reducing both the risk of N leaching into waterways causing eutrophication, and of N being released as N_2O to the atmosphere increasing the greenhouse

[545] https://doi.org/10.3390/su11195285

effect.[546] Furthermore, a wide number of soil protection measures are available that help retain water and reduce water needs, avoid salinisation and increase resilience to droughts.[547] Therefore, applying specific SSM practices that retain moisture, planting bushes and trees that generate shade, and cultivating plants and crop species and variants adapted to dry climatic conditions can reverse the trend towards desertification and restore soils already affected by it.[548]

Additionally, through improved and sustainable management of land and water resources, infiltration of water into soil can be improved, helping reduce standing surface water and the potential for ***flooding***. Healthy soils can infiltrate and store more water resulting in reduced flood and drought risks and improved water quality downstream.[549] Implementing SSM practices that help to reduce erosion can lead to positive off-site effects on water infrastructure, especially dams and other water reservoirs, due to less sedimentation (reduced dredging costs and maintenance costs).[550] Affected waters then require less treatment due to lower sediment load and reduced contamination.[551] Further, particular SSM practices in urban areas such as the implementation of green spaces and vegetation management, afforestation, and addition of green drainage infrastructures can maintain and improve soil health and reduce flooding within urban spaces and elsewhere downstream.

It is widely recognised that unsustainable SSM practices result in CO_2 losses from soils, while investing in soil health can sequester carbon, which supports the mitigation of ***climate change.***[552] The EU is aiming to be net zero by 2050. This will rely on carbon removals and carbon capture and storage through the better management of soils, with an aim to absorb the emissions that will remain at the end of an ambitious decarbonisation pathway.[553]

There are a range of impacts to climate associated with implementing particular SSM practices, for example, many have the ability to increase soil organic carbon (SOC). In comparison to moderate intensity tillage and high intensity tillage, no tillage enables the soil to maintain higher SOC concentrations and higher SOC stocks in the top layers of soils (0-15cm). No tillage also has higher SOC concentration and stocks in comparison to higher intensity tillage in 0-30cm soil depth.[554] While organic amendments can increase SOC stocks, depending on the soil type, climate, and management practices, they can lead to increase in the release of N_2O and CH_4.[555] Further, the paper makes a point that N_2O emissions can be increased by no tillage due to wetter and denser conditions, possibly offsetting the emissions of increased C sequestration from no tillage. Within forested areas, good forest management supports carbon sequestration due to better tree growth.

In a study that looked at four European countries (Sweden, United Kingdom, Czech Republic, and Greece) distributed across five locations in each country representing intensive annual crop rotation (high intensity (H)), extensive rotation, including legumes or ley (medium intensity (M)), or permanent grassland (low intensity (L)), it was found that at all sites, the three land use types were all methane sinks, and the intensive rotation and permanent grassland were stronger methane sinks than the extensive rotation.[556]

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[546] Ibid.
[547] Soil carbon insures arable crop production against increasing adverse weather due to climate change - IOPscience
[548] https://www.sciencedirect.com/science/article/abs/pii/S026483771830855X
[549] https://www.wbcsd.org/contentwbc/download/6149/85658/1
[550] Microsoft Word - EN_SEC_620.doc (europa.eu)
[551] *Ibid.*
[552] The_Business_Case_for_Investing_in_Soil_Health.pdf (wbcsd.org)
[553] EU Soil Strategy for 2030
[554] How does tillage intensity affect soil organic carbon? A systematic review | Environmental Evidence | Full Text (biomedcentral.com)
[555] 2022_SOIL_RISE_Foundation.pdf (risefoundation.eu)
[556] Soil food web properties explain ecosystem services across European land use systems (pnas.org)

Reducing or preventing erosion through SSM measures can also lead to a reduction in CO_2 and other GHG emissions through a reduction in the use of energy due to less machinery use (e.g., with reduced tillage) and contribution to carbon sequestration (due to, for instance, land use changes from agriculture to forestry)[557]. Reducing or preventing compaction through SSM measures results in similar reductions in CO_2. Further, healthy functioning soils support the mitigation of the urban heat island effect. SSM practices that support soil health in urban areas, such as controls on fertiliser and pesticide application in urban areas, will enable soils to function more naturally. Additionally, urban greening through reforestation, which is an SSM practices, has the dual effect of contributing to soil health while also contributing to the mitigation of urban heat island effects.

Intense land use (in agricultural and forested areas) increases bacterial biomass associated with N mineralisation which can become a problem when N supply is too great for crop need, and excess N is washed away in drainage waters or lost through the atmosphere through denitrification[558]. For example, the change of land use from arable cropping to unfertilised grassland (without livestock) and associated manure inputs could reportedly reduce NO_3 losses by around 90% (annual loss would typically be <5kg N/ha), direct and indirect N_2O and NH_3 emissions would be reduced by around 90%, as well as increased carbon storage initially in the range of 1.9 to 7.0 tCO_2eq/ha/year. However, this is at a cost of 200-3,500 £/farm (EUR 230-4,000) (depending on the farm system), as well as an impact on food security in the local area and potentially indirect land use change/carbon leakages.[559]

The climate benefits offered by restoration practices are re-iterated by the State of Finance for Nature report[560] by the UNEP, which explores annual investment in Nature-based solutions required to limit climate change to below 1.5°C, halt biodiversity loss and achieve land degradation neutrality. It estimates the potential for GHG removals by nature-based solutions globally over the period to 2050. Several sustainable land management measures show significant potential for GHG removals, in particular: cover crops (around 0.5$GtCO_2eq$ pa by 2050), and grazing-optimal intensity (around 1.5$GtCO_2eq$ pa by 2050).

SSM practices can also impact positively on ***Biodiversity*****.** Soil biodiversity is an indicator for soil health, as it supports the correct functioning of soil processes. In agricultural areas, no-till farming eliminates ploughing and reduces tillage operations to zero. Farmers implementing no-till plant their seeds through crop residues using machinery that 'cuts' soil to place the seed and closes it back.[561] Soil organisms, in particular earthworms and arbuscular mycorrhizal fungi (AMF), are positively affected by reduced tillage, which in turn reduces leaching of soil nutrients and loss of soil carbon,[562] as well as reducing soil erosion and maintains soil structure thereby increasing soil's water retention capacity. Foresters applying SSM practices such as continuous forest cover to protect soil, or encouraging understory growth to optimise soil vegetative cover to minimise evaporation losses will also in turn support biodiversity within forested areas.

One study found that the total biomass of the soil food web and biomass of the fungal, bacterial, and root energy channel (which consists of AMF, root-feeding fauna, and their predators) were all lower

[557] Microsoft Word - EN_SEC_620.doc (europa.eu)
[558] Soil food web properties explain ecosystem services across European land use systems - PubMed (nih.gov)
[559] Measures to decrease nitrate pollution in drinking water (fairway-is.eu)
[560] https://wedocs.unep.org/bitstream/handle/20.500.11822/41333/state_finance_nature.pdf?sequence=3
[561] https://risefoundation.eu/sustainable-agricultural-soil-management-in-the-eu-whats-stopping-it-how-can-it-be-enabled/
[562] https://doi.org/10.1186/s13750-017-0108-9

under medium and high land use categories relative to the lower land use category. The biomass of many individual feeding groups of soil biota was lower under these more-intensive land uses. This study indicates that, across contrasting sites in Europe, that land use intensification consistently reduces the biomass of all components of the soil food web, impacting on correct soil functioning[563]. There is also a positive relationship between soil biodiversity and control of greenhouse gases, retention of soil nutrients and biotic resistance to pests.[564]

The table below highlights a range of environmental benefits and costs related to the implementation of various SSM practices. The use of these practices can improve soil conditions (relative to a benchmark of soil health) and may lead to improved private economic benefits and public environmental benefits. Although some benefits are defined as 'environmental' in the short term, in the long-term these may provide a societal economic benefit. For example, increased carbon sequestration potential will reduce costs in the long term through their impact on the risk often related to climatic changes and may enable farmers to diversify their businesses and harness carbon sequestration as a separate income stream through carbon farming initiatives, where available. It should be noted that in the table below, reference to cover crops and tillage are examples of a wider group of measures.

Table 4-14: Environmental benefits and costs that have an impact on economic outcomes of SSM practice decisions, adapted from Rejesus et al.

Type	Potential Benefits (revenue increasing or cost decreasing)	Potential Costs (revenue decreasing or cost increasing)
Private (e.g., individual)	Environmental	
	Reduced soil erosion in fields and forests Decreased soil compaction Reduced nitrogen and phosphorus losses Increasing nutrient use efficiency Better moisture retention in season (after planting cover crops) Increased biodiversity	None
External (e.g., societal)	Environmental	
	Reduced soil erosion Carbon sequestration and climate change mitigation (e.g., cover crops or no-till sequester and store carbon in plant/soil) Improved water quality (e.g., from reduced nitrate leaching) Increased biodiversity (e.g., better environment for beneficial insects and pollinators) These benefits will result in stable food supply, healthy foods, clean water and air, flood prevention, healthy nature.	None

Spontaneous forest regrowth through natural succession is the main force driving the increase of forested areas in the EU, mostly associated with abandonment of agriculture and rural areas. However, there is potential for extending forest and tree coverage in the EU through active and sustainable re-and afforestation and tree planting, which when done correctly can be an effective SSM practice. The EU Forestry Strategy[565] notes that this is often relevant for urban and peri-urban areas (including e.g., urban parks, trees on public and private property, greening buildings and infrastructure, and urban gardens) and agricultural area (including e.g. in abandoned areas as well as through agroforestry and silvopastoral systems, landscape features and the establishment of ecological corridors). There is great potential in these areas to capitalise on the many benefits afforded from extending forest and tree coverage, such as improving soil structure and their function

[563] https://doi.org/10.1073/pnas.1305198110
[564] Microsoft Word - Final publ report Nov2012.docx (agrifood.se)
[565] resource.html (europa.eu)

to improve the ***quality of nature resources (soils)***, supporting water flow and regulation to reduce ***flooding***, and increasing ***biodiversity***.

SSM practices undertaken in urban areas can help provide green spaces and support biodiversity in the urban landscape. The majority of urban specific SSM practices are related to vegetation management, tree planting or reforestation, and fertiliser/pesticide application in green spaces such as public parks. Many areas in urban spaces are in need of restoration and remediation measures to improve them to a healthy status. The REST and REM sections below provide further details on this. For example, as noted below in the REST section, a LIFE funded project focused on urban land acquisition in the Spain to support nature conservation efforts in the area. This project enabled unhealthy and mixed-use urban areas to be acquired which could then undergo rehabilitation to its natural state.[566] This is an examples of the environmental benefits that can come from improving the health of soils, as part of nature rehabilitation in urban areas. With regard to SSM, restoration is typically something that needs to be enacted first as many urban soils may require intense action, greater than that of SSM, depending on the threat and how unhealthy the soil is. Once restored however, ongoing SSM should be continued to ensure the healthy condition is maintained. SSM can be viewed as an ongoing measure once a soil is restored to achieve and maintain soil health.

Environmental – Option 2

Under Option 2 (SSM2) there are wide ranging environmental benefits from the implementation of SSM practices, positively impacting the range of soil pressures such as erosion, compaction, SOC content, loss of SOM, and salinisation (etc). Environmental benefits can be seen across the areas of climate change, quality of natural resources (air, soil, water), and biodiversity. In comparison to the baseline of soil health in the EU, there is uncertainty over the level of improvements that will be realised from the implementation of SSM2. However, these improvements will also be significantly less than under SSM3 and SSM4.

Social

Water quality can be improved with implementation of SSM. As soil structure improves so does water filtration, and more effective nutrient management will reduce leaching of possible contaminants to water, thus improving ***public health and safety***, and reducing public costs associated with filtering water.[567] Likewise, there will be a public health benefit to reducing air pollution.

Implementing SSM practices will have an impact on ***employment.*** Some agricultural SSM practices are less labour intensive, which may improve farmers' well-being/work-life balance, which is particularly true on small farms. However, on larger farms, forests, and urban areas with employed work forces this reduced labour input may result in loss of employment. This is exemplified by the reduced tillage and crop rotation practices quantitatively assessed as part of the sample of 5 SSM practices: for reduced tillage, labour cost savings are a key component of the benefits of this measure, but this also implies a reduction in employment; labour cost savings are also counted as part of the benefits of crop rotation, although these are much less significant relative to the key savings of variable and machinery costs. Contrary to this, some practices can have a ***positive impact on employment*** and increase labour inputs such as needing manual weeding to replace/limit the use of pesticides.[568] Based on the estimated additional labour cost for the remaining 3 SSM practices in the sample of 5 illustrative practices quantitatively assessed, it is estimated that this could lead to a

[566] https://webgate.ec.europa.eu/life/publicWebsite/project/details/913
[567] https://www.wbcsd.org/contentwbc/download/6149/85658/1
[568] Documents (isqaper-is.eu)

direct employment effect of an additional 300,000 to 420,000 annual work units (AWUs)[569] per annum on an ongoing basis. There will also be additional indirect and induced employment effects as the impacts ripple through the economy. Although more uncertain than the estimate of direct effects, an estimate of the total employment effects is around 370,000 to 560,000 additional AWUs per annum on an ongoing basis. Further detail of the approach and results to estimating employment effects is presented in section 10. The impact of SSM on labour will be determined by the specifics of the SSM practices. As noted above, implementing SSM practices that aim to reduce salinisation/acidification can lead to the prevention of land abandonment and related unemployment due to desertification in the longer-term.[570]

URLMs knowledge increases with practicing SSM. This allows for increased engagement and encourages the development of new strategies and techniques,[571] as well as consolidating traditional techniques that support soil health. Several case studies that cover the implementation of SSM practices within agriculture specifically reported growth in networks of farmers, research organisations, and various other stakeholders, allowing knowledge transfer knowledge and support ***(education, networks)*** within a community.[572]

Changing public attitudes towards greater climate and sustainability awareness means that improving soil health, and ecosystems services as a result, will likely ***improve social perception of farming***, and enable farmers to continue with higher perceived credibility.[573]

With regard to forestry, there are many benefits to society from increasing forest cover in rural and urban areas. SSM practices that support afforestation can create substantial ***job opportunities***, e.g. in relation to collecting and cultivating of seeds, planting seedlings, and ensuring their development, as well as providing socio-economic benefits to local communities. Also, exposure to green and forested areas can greatly benefit ***people's physical and mental health.***[574]

Social – Option 2
Under Option 2 (SSM2) there are a range of social benefits positively impacting on public health and safety, education and networks, and improving the social perception of farming. In comparison to the baseline of the social impacts from soil health in the EU, there is uncertainty over the level of improvements to society that will be realised from the implementation of SSM2. However, these improvements will also be significantly less than under SSM3 and SSM4.

4.2.3 Distribution of effects

Under SSM 2, responsibility for implementation sits with ***Member States***, who will need to define SSM practices, and set out the mechanism needed to implement and monitor the progress.

Urban and rural land managers will be responsible for on the ground implementation of the required SSM practices per Member State. Implementation of SSM practices will incur CAPEX and OPEX costs – it is uncertain where these costs will fall and in what proportion, as this will be

[569] Annual work unit (AWU) is the full-time equivalent employment, i.e. the total hours worked divided by the average annual hours worked in full-time jobs in the country. One annual work unit corresponds to the work performed by one person who is occupied on an agricultural holding on a full-time basis.
[570] Microsoft Word - EN_SEC_620.doc (europa.eu)
[571] Documents (isqaper-is.eu)
[572] *Ibid*.
[573] https://www.wbcsd.org/contentwbc/download/6149/85658/1
[574] resource.html (europa.eu)

determined by the methods chosen by each Member State to drive adoption. However, the obligation to use soils sustainably falls to Member States and as such, this is where the costs will initially fall. It is important to note that URLMs may not reap all the benefits that are associated with the change. For some SSM practices, the benefits may take years to emerge, and/or take many years to 'payback'. Furthermore, although many SSM have the potential to deliver economic returns if implemented optimally, whether they do or not will depend on the measure type, location and the extent of implementation. In some cases, there may be a negative economic return (in the short term especially).

It should be noted that tenant farmers, contractors, foresters and other land managers who do not own the land they work on may benefit less from the positive impacts on soil health and consequently less economic benefits from improved yield in comparison to land owners and farmers. This is due to a range of barriers. For example, farm tenures can be short, meaning that agricultural and forestry SSM practices that take a longer time to see the positive effects on soil may not be implemented in following tenancies if it changes hands, rendering the tenant unable to capture all the benefit given the time limit of their tenancy agreement. Whereas in the case of a landowner managing the land, they may still not capture all the benefits of SSM but would in theory observe and be able to capture an increase in the value of land when their ownership ends. Some SSM practices can take up 10-20 years for the benefits to be seen, meaning that shorter tenancies will not see these benefits during their tenure.

Sustainable soil management measures are likely to predominantly impact rural areas. Although some measures will be delivered in urban areas, the measures will predominantly impact agricultural and forestry land – this represents a greater land area (around 80% of the EU's land area), soils are more actively managed, nutrients are applied in greater amounts and a lower proportion of rural land is inaccessible. As a consequence, the costs of implementing these measures will also fall more so on rural areas, but also the majority of the benefits of implementing these measures would also fall to rural areas (e.g. productivity improvements through increase in yield or input cost savings).

The ***general public*** (now and in the future) and future landowners and rural land managers (thanks to higher productivity in the future) will be potential gainers of implementation conservation measures.

4.2.4 Risks for implementation

A general risk associated is whether URLMs have sufficient expertise to implement the SSM. Improving the quality of education and access to education will be an essential step in ensuring the effective implementation of this building block across all potential options. Stakeholders noted that there is a need to anchor the shared experience of URLMs to build a toolbox and provide education, which can be done in a range of ways such as through improved national curriculum and programmes and workshops for URLMs. Some highlighted that education would be important in persuading URLMs to take action, by demonstrating the value in these actions. While some of this can be funded through the CAP for agricultural and some forestry specific education, Member States will also likely incur costs related to this as well.

An additional risk, highlighted by stakeholders is the financial aspect. Given many practices involve an upfront cost, and economic benefits (if any or if sufficient to outweigh the costs) accruing overtime, upfront investment could place a barrier to take up of measures. As noted, it is uncertain where the adjustment costs will fall and in what proportion, as this will depend on the delivery mechanisms put in place in each Member State.

Finally, with regard to tenant farmers, there is some risk around disputes between landowners and tenant farmers over implementing SSM practices that may have greater visible impacts on the land, such as tree planting. This may prevent such practices from being enacted, undermining the efficacy of this option.

Option 2
Option 2 provides greatest flexibility to Member States to choose and implement SSM practices. However, this flexibility drives greater uncertainty around which measures (particularly voluntary ones) will be implemented, to what extent and in what areas. Stakeholders noted that it is possible that Member States and landowners/managers may opt the minimum (e.g., race to the bottom) if too much flexibility is allowed. Where fewer measures are adopted by Member States and implemented by URLMs, this would reduce the adjustment costs but also the economic and environmental benefits associated with the measures. In response to the OPC, a Member State stated that this option (SSM2) was most relevant to ensure the effective adaptation of practices given the differing environmental and economic contexts of it and other Member States. However, leaving Member States to decide on which practices they can mandate or encourage the uptake of leaves room for harmful practices to continue without reparation.

4.2.5 Links /synergies

Soil degradation shall be avoided through the application of SSM practices, especially through the successful implementation of soil conservation approaches. Soil rehabilitation and restoration is also tackled under the REST building block, with the aim of returning degraded soils to productivity, especially in historically intensive agriculture areas or other production systems currently under threat. The SSM practices encouraged under SSM will work towards achieving the restoration goals set under REST. The level of subsidiarity opted for in the SSM options should depend on that chosen for other building blocks – especially with regard to REST. The minimum criteria provided under this option should be aligned with the options chosen for REST.

The responsibilities of determining a healthy form an unhealthy soil, and ongoing monitoring of the state of the soil/the effectiveness of the restoration process will depend on the options selected for building blocks SHSD and MON. In relation to SHSD building block, it should be noted that every soil region and/or district is different. Consequently, SSM practices are very different and can often be highly unique according to topography, climate, country culture etc. While it is widely recognised that all soils should benefit from SSM practices, definitions of soil health under the SHSD building block (and its ambition) will also affect how SSM practices are defined, enforced and regulated.

Determining a healthy soil from an unhealthy soil and ongoing monitoring of the state of the soil/the effectiveness of the restoration process will depend on the options selected for building blocks SHSD and MON. SHSD and MON building blocks will set the target for SSM and REST building blocks: the descriptors chosen for soil health indicators and districts (and also to a certain extent the sampling procedures) will play a key role in driving the level of ambition, and hence also the costs and benefits, of the option selected under the SSM building block.

4.2.6 Opinions of stakeholders

Opinions received on the obligation to use soil sustainably and apply the principle of non-deterioration are presented below, for each EU MS and major stakeholder type. Information was extracted from written feedback received from MS and other stakeholders.[575] EU MS generally support including definitions of sustainable soil use and non-deterioration in the SHL while stressing that a degree of MS flexibility is necessary considering different soil types, climate and other local conditions. Some however supported the inclusion of obligations, for elements backed by scientific consensus.

Table 4-15: Overview of stakeholder input on SSM

	Obligation to use soil sustainably and apply principle of non-deterioration
Austria	SHL should differentiate sustainable systems based on use; support principle of non-deterioration in relation to soil condition or soil/ecosystem status (national public authority).
Belgium	Support defining SSM obligations in order to preserve the entirety of the soil functions and ecosystem services (regional public authority).
Bulgaria	No answer provided
Croatia	No answer provided
Cyprus	No answer provided
Czech Republic	No answer provided
Denmark	No answer provided
Estonia	No answer provided
Finland	Support inclusion of general principles on sustainable use and non-deterioration, then refined in MS (national public authority).
France	Agree with the principle of sustainable use and non-degradation; support MS flexibility; support obligation and prohibition of certain practices in the SHL if recognised to be positive/negative regardless of soil type and climate (national public authorities, n=2).
Germany	Support principle of non-deterioration, which should be included in SHL; principles in SHL should be refined at MS level (national public authority).
Greece	No answer provided
Hungary	No answer provided
Ireland	No answer provided
Italy	Support non-deterioration, to be defined also in relation to other environmental impacts (e.g, air, water); support sustainable use of soil and land as general objectives (national public authority).
Latvia	No answer provided
Lithuania	No answer provided
Luxembourg	Support concepts of sustainable soil use and non-deterioration; support MS being obliged to undertake action for irrecoverable soil degradations on large scale; some general practices should be mandatory or banned at the EU level (national public authority).

[575] Note that opinions from OPC position papers for civil society and research and academia stakeholders are not synthesized here. Please see the synthesis of stakeholder consultations for more information on the views of these stakeholders.

Malta	No answer provided
Netherlands	Support MS flexibility; EC can provide guidance; the SHL should not be prescriptive in banning/obliging certain practices (national public authority).
Poland	No answer provided
Portugal	Practices related to SSM should be defined in the SHL; approach should consider local conditions; support the principle of non-deterioration with flexibility given to MS (national public authority).
Romania	No answer provided
Slovakia	No answer provided
Slovenia	Support the principle of non-deterioration; definitions in SHL must be clear and unambiguous (national public authority).
Spain	No answer provided
Sweden	Support including non-deterioration and sustainable use but argue it is preferable to rely on (and if needed amend) existing legislation (e.g., Nitrates Directive and WFD) (national public authority).
Other public authority	Support at least some degree of flexibility: one favours full flexibility and subsidiarity together with exchange of a harmonized monitoring, without obliging or banning practices;[576] another favours MS flexibility, except if there is a scientific consensus that a practice has a negative effect.[577] Support banning certain practices (e.g., peat extraction) and upper limits for N and P application on agricultural soils[578]
Farmers	Soil management practices should be defined per region, with involvement of local consultants and professionals[579] The full range of soil functions and features must be analysed and taken into consideration; surface sealing has to be strictly limited to protect fertile soils and valuable farmland.[580]
Foresters	No answer provided
Land owners / land managers	One supports non-binding, voluntary measures;[581] another supports ban on established damaging practices and flexibility, although with minimum safeguards[582]
Industry (businesses and business associations)	MS should have flexibility to apply SSM (n=4);[583] farmers should have flexibility in practices they implement;[584] minimal common standards across MS; support for a risk-based framework; [585] demarcation with existing requirements must be ensured (IED);[586] one is against SHL containing prescriptive obligations or prohibitions of practices,[587] or banning should be limited to practices proven to be very harmful;[588] another supports obligation to not cause further degradation to soils.[589]
Civil society	No answer provided

[576] Common Forum
[577] Norwegian national public authority
[578] Norwegian national public authority
[579] CIVC Champagne
[580] IFOAM
[581] ELO
[582] NICOLE
[583] Cefic *(ESEG)*, Concawe, Eurometaux, Food Drink Europe
[584] Food Drink Europe
[585] Concawe
[586] Cefic
[587] Cefic
[588] Concawe
[589] Food Drink Europe

(NGOs)	
Research and Academia	Support MS flexibility[590]

Summary assessment against indicators

The number of SSM practices that can be done to improve soil health is extensive, each with differing effects on the wide range of soil health pressures such as erosion, compaction, and salinisation, etc. Some SSM practices have a positive economic impact alongside their economic cost, providing an overall benefit, whereas other practices have lower economic benefit. Further, the impacts are highly dependent on location, crop or livestock type, soil type, and climate, meaning there is high variability. In terms of timeframe, some practices can have more immediate positive effects, but most are much longer time, in the areas of 10+ years. However, to avoid the continually high economic losses associated with poor soil health pressures and continued degradation, implementing SSM practices now will enable greater returns in the future. If SSM practices can be tailored to individual farms (such as through soil management plans) and effectively implemented, there is a greater opportunity for longer term positive economic effects.

Option 2 delivers an improved governance structure as it places responsibility for the first time on provide Member States to use soil sustainably. For this Option (SSM2), there is a positive impact on soil health, but to a lesser extent in comparison to Option 3, as all actions are left to Member States in SSM2. The greater flexibility afforded to Member States means that the implementation of SSM practices across the EU will be variable, with some Member States taking more action than others, and therefore meaning that URLMs have to do more to achieve soil health. Further, as Member States and ultimately URLMs having less obligation to implement SSM practices, there are greater risks for SSM2 in terms of the level of positive environmental (and economic) impact. Overall, there are high adjustment costs under this measure, but these costs are lower than option 3, as Member States have less obligations. The administrative burden is low. The distribution of costs/benefits is an issue; however, this is relevant across all options under SSM.

Table 4-16: Overview of impacts for option 2

Effectiveness	**Impact on soil health**	++	SSM practices will deliver significant environmental benefits through improvements to soil health. However, leaving flexibility to Member States risks a race-to-the-bottom, with some potentially taking insufficient action to prevent continuing degradation of soil health and others may leave room for harmful practices to continue without reparation
	Information, data and common governance on soil health and management	++	Important benefit of the option, in particular obligation placed on Member States of non-deterioration and to use soil sustainably
	Transition to sustainable soil management and restoration	++	Option delivers significant benefit, in particular obligation on Member States to use soil sustainably. But high delivery risk curtails benefit relative to Option 3
Efficiency	**Benefits**	++	Impact on soil health key benefit
	Adjustment costs	---	Implementation of SSM practices will incur substantial cost. Total cost will be driven by exact set of practices delivered (costs likely to be lower under Option 2 vs 3, but still large – in EUR 10's billions)
	Administrative burden	-	Low relative to other options (< EUR 1m upfront or pa)
	Distribution of costs	--	Uncertain where costs of implementing SSM practices will fall.

[590] Royal Swedish Academy of Agriculture and Forestry

	and benefits		URLMs will have an important role but would not capture all the benefits. This is particularly the case for tenant land managers.
Coherence		+	Option coherent with options under other building blocks
Risks for implementation		---	High risk of inconsistency in the implementation and ambition across Member States – some may implement a minimum or limited number of recommendations and restrictions

4.3 SSM – Option 3: Obligation to use soils sustainably; supported by some common general principles for SSM while definition of SSM is left to Member States

4.3.1 Description of option and requirements for implementation

The SHL provides a common definition of sustainable soil management and includes the obligation to use soil sustainably. Option 3 includes:

- The SHL includes a list of SSM principles which will be mandatory
- Member States are obliged to enforce these for land managers and other relevant stakeholders to undertake
- Principles could include those similar to the CAP GAEC standards that support soil health.
- Member States would still retain fullflexibility concerning the implementation of specific management practices and can choose to apply additional requirements going beyond the minimum list of mandatory principles

Principles included in the annex may be similar to those under the GAECs. Currently, GAECs are mandatory under the CAP, and are estimated to cover up to 90% of agriculturally productive land in the EU. The indicated SSM principles will apply to all agricultural land, as well as to other land types, such as forestry and urban areas where SSM is applicable.

4.3.2 Assessment of impacts

Economic – Option 3

The key difference between SSM2 and SSM3 is that under SSM3, certain management principles are mandated, which increases both the extent of practices (in which the principles will have to be translated) being implemented (and therefore an increase in adjustment costs across the EU), and increases the economic benefits reaped from improving soil health. However, there is still uncertainty over the list of principles that will be mandatory, and therefore making it hard to concretely say how much the increase in economic benefits will be. The enforcement of SSM principles on agricultural and non-agricultural land will mean that environmental benefits will be more widespread and will have a greater positive environmental impact than SSM2. This in turn will see economic benefits for URLMs and for wider society, where pressures to soil are alleviated and costs from erosion, compaction, and salinisation (and other soil health pressures) are reduced.

A second difference in the impacts relative to those assessed under the Option 2 is there is a likelihood that there will be some marginal increased costs and ***administrative burdens*** for Member States due to need to enforce SSM principles on a wider scale than currently and to obligate relevant stakeholders to undertake SSM practices.

Through the implementation of Option 3, it will be up to the EC to produce SSM principles. An estimate of additional administrative burden places the upfront burden at around EUR 432,000 for the EC which includes a consultant study costing around EUR 250,000. For Member States, the administrative burden of option 3 will likely to be higher than option 2 considering the follow up on those SSM principles is mandatory (0.5 FTE or EUR 675,000). Total upfront administrative burden cis estimated to be around EUR 675,000 for Member States and EUR 432,000 for the EC.

Table 4-17: Total administrative burden across SSM options

Option number	EC – One-off costs	EC – Recurrent costs	MS – One-off costs	MS – Recurrent costs	Other – One-off costs	Other – Recurrent costs	TOTAL – one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 3	29,000	24,000	45,000	-	-	-	74,000	24,000

Environmental – Option 3

The enforcement of SSM on agricultural and non-agricultural land will mean that environmental benefits from SSM practices will be more widespread and will have a greater positive environmental impact then SSM 2. This is particularly the case for forested land, where minimum standards, such as GAECs, are not currently mandated on land set aside for commercial forestry. Similarly for urban areas, having stronger regulations over SSM will have a greater positive impact on reducing environmental harms. This in turn will see economic benefits for URLMs and for wider society as noted above.

Social – Option 3

No difference in assessment to those assessed for Option 2.

4.3.3 Distribution of effects

The distribution of effects will be broadly similar to that for the Option 2. One difference under Option 3 is that as a range of SSM principles will become mandatory under this option, there will be a greater number of URLMs that will be affected. That said, where the costs will fall is uncertain and will depend on the method of implementation by each Member State.

4.3.4 Risks for implementation

There are several risks for the implementation of this option (SSM3) further than what is already considered under SSM2.

Firstly, due to certain principles being mandated, there is less risk of variation than under SSM2. However, the additional benefit from enforcing certain SSM principles, e.g. similar to those that are already mandated in agricultural areas through GAECs specifically, is marginal. Over 125.9 million hectares in the EU are already subject to mandatory GAECs under the CAP (referred to the CAP period until 2022) hence where some practices and/or principles are implemented that are similar to the GAECs, the additional impact of these principles and/or practices specifically may be more limited.

Second, stakeholders noted the risk of having overlapping legislation regulation soil management on agricultural land on top of current requirements under the CAP. They highlighted that doing so could drive unnecessary cost, administrative and labour burdens on URLMs. Consequently, they recommended that there is minimal crossover between the Soil Health Law and other legislation.

4.3.5 *Links /synergies*

The level of subsidiarity opted for in the SSM options should be consistent with that chosen for other building blocks – especially with regard to REST. The minimum criteria provided under this option should be aligned with the options chosen for REST.

The responsibilities of determining a healthy form an unhealthy soil, and ongoing monitoring of the state of the soil/the effectiveness of the restoration process will depend on the options selected for building blocks SHSD and MON. In relation to SHSD building block, it should be noted that every soil region and/or district is different. Consequently, SSM practices are very different and can often be highly unique according to topography, climate, country culture etc. While it is widely recognised that all soils should benefit from SSM practices, definitions of soil health under the SHSD building block (and its ambition) will also affect how SSM practices are defined, enforced and regulated.

Determining a healthy soil from an unhealthy soil and ongoing monitoring of the state of the soil/the effectiveness of the restoration process will depend on the options selected for building blocks SHSD and MON. SHSD and MON building blocks will set the target for SSM and REST building blocks: the descriptors chosen for soil health indicators and districts (and also to a certain extent the sampling procedures) will play a key role in driving the level of ambition, and hence also the costs and benefits, of the option selected under the SSM building block.

4.3.6 *Summary assessment against indicators*

For all options, there is a need for improved governance to provide Member States with the obligation to use soil sustainably. For this option (SSM3), there is a greater positive impact on soil health in comparison to SSM2, as some SSM principles become mandatory under SSM3. Notably, this depends on the options chosen under this measure; for example, there may be ‘softer’ measures that the EC can recommend in the legislative annex, such as training and education for better management, or farm, plantation, or urban site-level management plans. Furthermore, as Member States and ultimately URLMs having more obligation to implement SSM practices following certain principles, like those that are similar to GAECs, there is a lower risk of inconsistency across Member States in terms of the level of positive environmental (and economic) impact.

Overall, there are high adjustment costs under this measure for both the EC and Member States; these costs are higher than SSM2 but lower than SSM4. The administrative burden is low. The distribution of costs/benefits is an issue; however, this is relevant across all options under SSM.

Table 4-18: Overview of impacts for option 3

Effectiveness	**Impact on soil health**	+++	SSM practices will deliver significant environmental benefits through improvements to soil health. Some implementation risks remain, but overall deemed lower than Options 2 and 4, hence benefits anticipated to be greatest under this option.
	Information, data and common governance on soil health and management	++	Important benefit of the option, in particular obligation placed on Member States of non-deterioration and to use soil sustainably.
	Transition to sustainable soil management and restoration	+++	Option delivers significant benefit, in particular obligation on Member States to use soil sustainably. Given lowest risk of implementation, anticipated to deliver greatest benefit
Efficiency	**Benefits**	+++	Impact on soil health key benefit

	Adjustment costs	---	Implementation of SSM practices will incur substantial cost – in EUR 10's billions. Total cost will be driven by exact set of practices delivered
	Administrative burden	-	Low relative to other options (< EUR 1m upfront or pa)
	Distribution of costs and benefits	--	Uncertain where costs of implementing SSM practices will fall. URLMs will have an important role, but would not capture all the benefits. This is particularly the case for tenant land managers.
Coherence		+/-	Option fairly coherent with options under other building blocks
Risks for implementation		--	Some risk of variability across Member States remains, but lower than Option 2. Some risk around universal applicability of mandated principles remains, but lower than Option 4, in particular as regards those principles similar to the GAECs, which are widely accepted under CAP.

4.4 SSM – Option 4: Obligation to use soils sustainably; comprehensive set of EU-wide SSM practices mandated

4.4.1 Description of option and requirements for implementation

Common Options:

- The SHL provides a common definition of sustainable soil management and includes the obligation to use soil sustainably

Option 4:

- The SHL indicates a list of SSM principles and certain mandatory and banned practices. MS can go beyond the list, but some or all of these elements will be mandatory
- MS must create a mechanism setting out the process and plan that obligates the relevant stakeholders to implement the SSM
- MS to translate SSM principles into requirements for SSM for a given land use and ensures banned practices are no longer carried out

Stakeholders noted that if the EC and Member States can agree that certain practices are dangerous for soil (such as burning arable stubble, clear felling, and peat extraction), then they should be banned explicitly in the law. That said, stakeholders also highlighted that the argument behind the obligation of practices or the banning of practices needs to be very clear to enhance compliance.

4.4.2 Assessment of impacts

Economic – Option 4

The key difference between SSM3 and SSM4 is that under SSM4, certain practices would be mandated and certain practices banned. This would likely increase the extent of practices being implemented, and therefore increases the adjustment costs across the EU. However, there will also be far greater increases in the economic benefits from improving soil health under this option (SSM4) in comparison to SSM3. As with SSM3, the enforcement of SSM principles and practices on agricultural and non-agricultural land will mean that environmental benefits will be more widespread and will have a greater positive environmental impact than SSM 2. This in turn will see greater economic benefits for URLMs and for wider society, where pressures to soil are alleviated and costs from erosion, compaction, and salinisation (and other soil health pressures) are reduced, but also much more significant costs given the range, location and extent of implementation is likely to be greater relative to other options.

A second difference is in terms of ***administrative burden***, where there will likely be lower costs for Member States, as the EC is leading on much of the administrative side of this option (e.g., EC to define harmful practices, EC to define list of mandatory and voluntary practices). There is a likelihood that there will be some small increased costs and administrative burdens for Member States due to need to enforce certain practices on a wider scale than currently and setting out a programm of measures to obligate relevant stakeholders to undertake the necessary measures. The EC would also incur upfront administrative burden associated with defining a comprehensive annex listing SSM practices requiring a more detailed consultation with Member States than option 3 (EUR 863,000) and ongoing costs to conduct reviews of the soil management plans (0.4 FTE per annum).

Table 4-19: Total administrative burden across SSM options

Option number	EC – One-off costs	EC – Recurrent costs	MS – One-off costs	MS – Recurrent costs	Other – One-off costs	Other – Recurrent costs	TOTAL – one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 4	76,000	48,000	4,800,000	-	-	-	4,900,000	48,000

Environmental – Option 4
The inclusion of mandatory SSM practices under this option will mean that environmental benefits will be more widespread and will have a greater positive environmental impact than SSM2. This is particularly the case for urban areas, where few SSM practices are currently mandated. This in turn will see economic benefits for URLMs and for wider society as noted above.

Further, under this option (SSM4), harmful practices defined at the EU level will be banned. This will have a strongly positive impact on the environment if practices such as deforestation, overgrazing, burning, and intensive cultivation, to name a few, are banned. Felling trees in a managed woodland is part of good forestry practice in maintaining forest health, but clear felling affects soil health by declining soil fertility and soil organic carbon pools in the forests[591]. Further, deforestation opens up areas of land to the wind and the weather, meaning recently felled areas are more susceptible to erosion, particularly when felling occurs on steeps slopes without careful consideration of which trees should be maintain. Overgrazing is specifically linked to compaction; high densities of livestock within an area significantly increases compaction and associated pressures, such as greater water run-off leading to greater instance of flooding.

Social – Option 4
No difference in assessment to those assessed for Option 2.

4.4.3 Distribution of effects

The distribution of effects will be broadly similar to that for the Option 2. The ***EC*** will bear additional costs for this measure (more in comparison to SSM2 and SSM3) associated with setting out the legislative annex. In comparison to SSM3, the mandating and banning of a greater number of specific practices will require more stringent enforcement, monitoring, and reporting by ***Member States*** to ensure that those practices are effectively banned on the ground. Relative to Options 2 and 3, a greater number of URLMs, will be engaged in the implementation of SSM practices.

[591] Effect of Deforestation and Forest Fragmentation on Ecosystem Services | SpringerLink

4.4.4 Risks for implementation

A major risk for this option is the challenges associated with the EC defining a list of measures that are applicable to the entirety of the EU, covering differences between all Member States and districts. As noted above, the impacts, effectiveness and applicability of different SSM practices varies by type, location and extent of deployment. A practice may not be sustainable in all circumstances, likewise a practice deemed unsustainable may be desirable in specific circumstances. Hence a key risk to Option 4 is where SSM are defined, there are likely to be location-specific circumstances which may mean practices are not viable universally (and/or it would take significant time, and increase the complexity, to define the list of mandatory or banned SSM). This risk was confirmed by a number of stakeholders who noted that every soil region and district is different, hence appropriate soil management would need to differ according to topography, and other location specific parameters. For example, the impact of spreading organic manures/fertilisers etc. on compaction/density of the soil needs to be considered as there is a risk that the amendments/machinery required to apply them can harm the soil structurally. As a result of this, expert stakeholders noted that it is difficult to give detailed instructions on EU-level and there is a benefit to having flexibility to define required SSM practices differently according to each soil district. Others also highlighted the belief that there is room to further encourage sustainable management, without mandating action. As a result it would be challenging to define measures that are universally applicable – this risk may manifest itself in either a protracted implementation timeline (delaying SSM being put in place), the list being rather limited (hence with little or marginal additional value over Option 2) and/or the list being necessarily high-level, limiting its effectiveness or requiring further application by Member States (although some stakeholders did not necessarily see an issue with measures being defined at a high-level). If a longer list is decided on that is not tailored to each Member States, there will be inefficiencies and a lack of meaningful implementation on the land. There is a high risk of push back from URLMs, as well as agricultural, forestry, other land use, and urban planning and construction associations and industry stakeholders alongside Member States on this option, particularly if there is a lack of applicability in the list of mandated measures. While there may be options such as including softer measures such as education and training or farm, plantation, or site-management plans, defining a list of universally applicable measures to implement will be difficult. This risk is greatest for Option 4.

As noted under Option 3, stakeholders flagged the risk of having overlapping legislation related to soil management on agricultural land specifically, which could increase administrative burden and complexity for farmers and agricultural land managers. Given the aim is to define a longer list of practices that are mandated or prohibited, this risk is largest under this option.

Stakeholders also noted that mandatory practices are very sensitive for the farming community. This is often also the case for foresters, urban planners, and other URLMs. As such, there is a need for a minimum requirement from all Member States so there is a level playing field. There would also need to be justifiable outlines for which practices are mandated and which are banned, and whether this will be defined by soil district and soil health definition under the SHSD building block.

4.4.5 Links /synergies

The level of subsidiarity opted for in the SSM options should be consistent with that chosen for other building blocks – especially with regard to REST. The minimum criteria provided under this option should be aligned with the options chosen for REST.

The responsibilities of determining a healthy form an unhealthy soil, and ongoing monitoring of the state of the soil/the effectiveness of the restoration process will depend on the options selected for building blocks SHSD and MON. In relation to SHSD building block, it should be noted that every soil region and/or district is different. Consequently, SSM practices are very different and can often be highly unique according to topography, climate, country culture etc. While it is widely recognised that all soils should benefit from SSM practices, definitions of soil health under the SHSD building block (and its ambition) will also affect how SSM practices are defined, enforced and regulated.

Determining a healthy soil from an unhealthy soil and ongoing monitoring of the state of the soil/the effectiveness of the restoration process will depend on the options selected for building blocks SHSD and MON. SHSD and MON building blocks will set the target for SSM and REST building blocks: the descriptors chosen for soil health indicators and districts (and also to a certain extent the sampling procedures) will play a key role in driving the level of ambition, and hence also the costs and benefits, of the option selected under the SSM building block.

4.4.6 Summary assessment against indicators

For all options, there is a need for improved governance to provide Member States with the obligation to use soil sustainably. For this option (SSM4), there is a greater positive impact on soil health in comparison to SSM3, given certain practices will be mandated and others banned. Notably, some of this positive impact depends on the options chosen under this measure; for example, there may be 'softer' measures that the EC can recommend in the legislative annex, such as training and education for better management, or farm-level management plans.

Further, as Member States and ultimately URLMs have more obligation to implement SSM practices and stop others there are higher risks for SSM4 in defining and mandating such practices. This will take time and is a highly complex task, and there will likely be push back from Member States and other stakeholders.

Overall, this option has the highest adjustment costs for both the EC and Member States, as well as URLMs. The administrative burden is low. The distribution of costs/benefits is an issue; however, this is relevant across all options under SSM. Further, this option is slightly less coherent with other building blocks. If this option is chosen, then other building blocks must similarly maintain the same level of ambition.

Table 4-20: Overview of impacts for option 4

Effectiveness	**Impact on soil health**	++	SSM practices will deliver significant environmental benefits through improvements to soil health. However, leaving EC attempting to define complete list of sustainable and harmful practices is highly risky, and could lead to implementation of ineffective, inefficient or harmful practices in some circumstances. Hence benefit lower relative to Option 3
	Information, data and common governance on soil health and management	+++	Important benefit of the option, in particular obligation placed on Member States of non-deterioration and to use soil sustainably. Obligation to develop soil management plans in all districts provides additional benefit
	Transition to sustainable soil management and restoration	++	Option delivers significant benefit, in particular obligation on Member States to use soil sustainably. But high delivery risk curtails benefit relative to Option 3
Efficiency	**Benefits**	++	Impact on soil health key benefit
	Adjustment costs	---	Implementation of SSM practices will incur substantial cost – in EUR 10's billions. Total cost will be driven by exact set of practices delivered

	Administrative burden	--	Moderate relative to other options (EUR 1m – 5m upfront), given requirement to develop soil management plan for all districts
	Distribution of costs and benefits	--	Uncertain where costs of implementing SSM practices will fall. URLMs will have an important role, but would not capture all the benefits. This is particularly the case for tenant land managers.
Coherence		+/-	Option less coherent with options under other building blocks
Risks for implementation		---	EC defining a list of mandated and prohibited practices that are applicable EU-wide, covering differences between all Member States, localities, climates, soil types, agricultural systems, and cultural norms is a highly technical challenge. Could protract delivery timeframe, lead to high-level list or practices not tailored to location specific variables.

5 DEFINITION AND IDENTIFICATION OF CONTAMINATED SITES (DEF)

5.1 Overview

5.1.1 Building block outline

The objective of this building block is to identify, register, investigate, and assess all (potentially) contaminated sites (CSs and PCSs) in the EU and to make this information publicly available in the form of (potentially) contaminated site inventories. The inventories would list the number of sites with different management statuses in each Member State. This information is critical to direct remediation efforts to contaminated sites and to manage contamination that would otherwise continue, or have potential, to harm human health and the environment. In this context, the NICOLE[592] network has been providing guidance on how to achieve sustainable remediation. Through its working group (Sustainable Remediation Work Group) deliveries, NICOLE has facilitated material to enable the European industry to identify, assess and manage industrially contaminated land efficiently, cost-effectively, within a framework of sustainability.

Overall, this building block 4, in combination with the measures set out under building block 5 on soil restoration and remediation, aims to support the zero pollution ambition for 2050 under the European Green Deal by reducing soil contamination to levels no longer considered harmful to human health and the environment. Holistically addressing the problem of soil contamination across Europe is dependent on identifying all contaminated sites across the EU, as set out in this building block.

5.1.2 Problem(s) that the building block tackles

This building block works towards tackling the following problems identified in the intervention logic:

- **Main problem** – Soils in the EU are unhealthy and continue to degrade.
- **Sub-problem A** – Data, information, knowledge and common governance on soil health and management are insufficient.

Description – The lack of general compulsory requirements to identify, register, investigate and assess (potentially) contaminated sites has resulted in significant gaps in EU-wide data on the number, spread and risks from contaminated soils. These gaps prevent targeted action to remediate

[592] NICOLE is a forum on industrially coordinated sustainable land management in Europe https://nicole.org/; https://www.eugris.info/newsdownloads/GreenRemediation/pdf/A04_OlivierMaurer_Paper.pdf

contaminated land and consequently, humans and the environment continue to be put at risk from an unknown, and potentially extensive, number of contaminated sites across the EU. Building block 4 is a prerequisite for remediation and risk reduction, and therefore the management measures of block 5 are wholly dependent on this building block for definition and identification.

Drivers – The lack of definitions and requirements for identification, investigation and risk assessment of soil contamination at EU level is due to regulatory gaps, e.g. at EU level, there is no binding framework for soil health[593] (only fragmented provisions as described in the table below). Member State regulations and policies for soil vary substantially, further driving this problem and leading to inconsistencies between Member States.

5.1.3 Baseline

Existing provisions for defining and identifying contaminated sites

The table**Error! Reference source not found.** below describes the existing relevant international and EU policies that are relevant for the identification, registration, investigation and assessment of (potentially) contaminated sites.

Table 5-1: Policies relevant to baseline for DEF

Policy	Relevant Component	Relevance to Definition and Identification of Contaminated Sites
Minamata Convention on Mercury	Article 12 (1) Contaminated sites	The Minamata Convention is a global agreement adopted in 2013 that addresses specific human activities which are contributing to widespread mercury pollution. Article 12 (1) establishes that parties shall develop strategies for identifying and assessing sites contaminated by mercury or mercury compounds.
Industrial Emissions Directive (IED) (2010/75/EU)	Article 3 Definitions	The IED provides definitions of terms related to contamination statuses such as 'pollution', 'installation', 'emission', 'emission limit values', 'hazardous substances', 'baseline report', 'groundwater', and 'soil'.
	Chapter II Provisions for Annex I activities Article 22 Site closure	Annex I defines categories of industrial emissions activities (i.e. activities which are potentially polluting).[594] The provisions of Chapter II require operators of such activities to apply for permits for these activities, providing information on the activity, potential emissions, and measures to prevent emissions. Operators should describe the nature, quantity, and sources of emissions (Article 12). Provisions for operators to monitor emissions and soil contamination are set out by Article 14, 16, and 22. Information on soil contamination should be set out in a baseline report.[595] In this way, a comparison can be made of the land condition before and after the activity has taken place to assess whether the activity has caused significant pollution. Article 23 sets out further provisions for Member States to inspect installations to examine environmental effects, which may include site contamination. Overall, these provisions are relevant to this building block as they provide a basis for identifying potentially polluting activities and where these activities are taking place, supporting the identification of PCSs.
Environmental Liability Directive (ELD)	Article 2 Definitions	Land damage is defined as any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction, in, on or under land, of substances, preparations, organisms or micro-organisms;
	Article 3 Scope and Annex	The ELD places the responsibility for remediation of land damage on

[593] https://ec.europa.eu/environment/soil/soil_policy_en.htm

[594] This list includes: 1. Energy industries; 2. Production and processing of metals; 3. Mineral industry; 4. Chemical industry; 5. Waste management; 6. Other activities. Further specificity for each category is given in Annex I, for example, for the first category, six types of activities are described. Differing levels of specificity for each category are provided, e.g., production of coke is included generally, while combustion of fiels is included when the total rated thermal input is 50 MW or more.

[595] The European Commission has produced a Guidance document with different stages to prepare the baseline report. These stages include: Stage 1: Identifying the hazardous substances that are currently used, produced or released at the Installation; Stage 2: Identifying the relevant hazardous substances; Stage 3: Assessment of the site-specific pollution possibility; Stage 4: Site history; Stage 5: Environmental setting; Stage 6: Site characterisation; Stage 7: Site investigation; Stage 8: Production of the baseline report.

Policy	Relevant Component	Relevance to Definition and Identification of Contaminated Sites
	III Activities	polluters (implementing the Polluter Pays Principle). Annex III sets out a list of occupational activities which may cause environmental damage[596] and therefore could be relevant to identifying PCSs.
European Pollutant Release and Transfer Register (E-PRTR) Regulation (166/2006/EC)	Annex I	Similar to the IED, Annex I defines categories of industrial emissions activities (i.e. activities which are potentially polluting). The list is the same as the IED list, however, with nuances in the description of specific activities within each category. E.g. under category 1 "energy sector", more specific details are provided in the E-PRTR Regulation compared to the IED.
	Article 5 Reporting by operators Article 6 Releases to land	According to the E-PRTR Regulation, operators must report the pollutants releases to soil.
INSPIRE Directive (2007/2/EC)	Annex III Spatial data themes Technical guidelines / data specifications for soil	The INSPIRE Directive sets out provisions for Member States to establish spatial data infrastructures in a standardized and interoperable way for 34 environmental themes, including soil. INSPIRE does not require the collection of new data, but Member States are required to monitor their implementation and use of the infrastructure. The technical guidelines on soil provide "use cases" related to contaminated sites[597] and note that although there are no explicit constructs for contamination, it is included implicitly by the possibility of specifying contamination parameters for sites. The JRC (2018) noted that 10 Member States have applied INSPIRE standards to spatial data on CSs and remediated sites.[598] Furthermore, the INSPIRE technical guidelines on soil describe Austria's CS inventory as an example case for applying INSPIRE, indicating the relevance of this directive to CS inventories which are provided for under this building block.

Contaminated site definitions and inventories have not been legally established across the EU. JRC (2018) presented six possible "site statuses" to identify the different steps in the management process in data collected from Member States. These were set out in the 2011 data request for the indicator on progress in management of contaminated sites (CSI 015) and also used in the JRC (2018) assessment of the status of local soil contamination in Europe. The statuses include:

- Status 1: sites where polluting activities took/are taking place (suspected PCS);
  - 1a: estimated
  - 1b: registered
- Status 2: sites in need of investigation (PCS);
  - 2a: estimated / in need of investigation
  - 2b: where investigation is on-going or complete
- Status 3: sites that have been investigated but no remediation is needed;
- Status 4: sites that need or might need remediation or risk reduction measures (RRM) for CS with unacceptable risk;
  - 4a: where remediation is needed
  - 4b: where remediation might be needed
- Status 5: sites under/with ongoing remediation or RRMs (CS with unacceptable risk); and
- Status 6: site remediation or RRMs completed or sites under aftercare measures.[599]

[596] The list includes: 1. The operation of installations subject to permit in pursuance of Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control; 2. Waste management operations; 3. Discharges into the inland surface water; 4. Discharges of substances into groundwater
5. The discharge or injection of pollutants into surface water or groundwater which require a permit, authorization or registration; 6. Water abstraction and impoundment of water subject to prior authorization.
7. Manufacture, use, storage, processing, filling, release into the environment and onsite transport of (a) dangerous substances; (b) dangerous preparations (c) plant protection products (d) biocidal products.
8. Transport by road, rail, inland waterways, sea or air of dangerous goods or polluting goods; 9. The operation of installations subject to authorisation in pursuance of Council Directive 84/360/EEC of 28 June 1984 on the combating of air pollution from industrial plants; 10. Any contained use, including transport, involving genetically modified micro-organisms ; 11. Any deliberate release into the environment, transport and placing on the market of genetically modified organisms; and, 12. Transboundary shipment of waste.
[597] INSPIRE Data Specification for the spatial data theme Soil, Annex B, Available: https://inspire.ec.europa.eu/id/document/tg/so
[598] Austria, Czechia, Netherlands, Estonia, Germany, Italy, Latvia, Portugal, Slovakia, Slovenia. JRC (2018), p. 49.
[599] JRC (2018), Status of local soil contamination in Europe. 14 and 15.

These statuses are not interpreted and used consistently by voluntarily reporting Member States. For example, the JRC (2018) report asked Member States to report site status 2a and 2b: some reported both, others reported only one or the other, and in some responses, it is unclear whether the reported value refers to 2a or 2b.

The European Environment Agency (EEA) has established common definitions related to contaminated sites:[600]

- A "**contaminated site**" (CS) is a defined area where the presence of hazardous substances has been confirmed and this presents a potential risk to the environment and human health.
- A "**potentially contaminated site**" (PCS) is a site where unacceptable soil contamination is suspected but not verified, and where detailed investigations need to be carried out to verify whether there is an unacceptable risk of adverse impacts on protection targets (such as human health and ecosystems).

A critical aspect of the identification of PCSs (and consequently CSs) is the scope of polluting activities used to identify PCSs. Member States do not currently share common definitions for soil polluting activities, despite the existing list of activities under the ELD and IED (see the table above). For instance, some countries recognise airports, ports and military sites as polluting activities, although they are not specifically listed currently under the ELD and IED. In France, ports and former military sites are not recognised as polluting activities and in Austria none of these activities are recognised. In Italy there is no list of potentially polluting activities for the identification of contaminated sites. In Luxembourg, there is uncertainty regarding whether certain registered sites[601] are truly where polluting activities are taking or have taken place.[602] The breadth of polluting activities recognised by Member States strongly influences the number of PCSs expected to be identified, therefore contributing significantly to the uncertainty regarding the number of PCSs and CSs across the EU.

Various EU-wide activities have been undertaken to generate an overview of EU data on soil contamination. For example, ESDAC was established in 2006 to gather and present EU soil data in a harmonised way, and quality control measures included data conformity checks by ESDAC data managers and cross-checking with national/regional data by experts from the European Soil Bureau Network and EIONET. The INSPIRE Directive (2007/2/EC) implicitly facilitates data on soil contamination to be maintained, e.g. Austria's contaminated land register is considered a "use case" of the spatial data infrastructure.[603]

Member States have previously been requested to submit data on the management of contaminated sites through the EEA Indicator LSI003 (formerly named CSI015[604]) 'Progress in the management of contaminated sites in Europe'. This indicator established voluntary exchange of definitions, statistics, methodical background, by country, based on questionnaires among the National Reference Centres

[600] Terminology related to contaminated sites — European Environment Agency (europa.eu)
[601] A "site" is defined as a particular area of land related to a specific ownership or activity (Van-Camp et al., 2004). PCSs are registered when a suspicion that a polluting activity is taking place is confirmed.
[602] JRC (2018). Status of local soil contamination in EuropeQ2. p.105-111.
[603] D2.8.III.3 INSPIRE Data Specification on Soil – Technical Guidelines. P.20, P. 218
[604] Soil Contamination - ESDAC - European Commission (europa.eu)

(NRC) Soil.[605] The most recent update, in December 2022, was based on an update of the data collected by the JRC in 2016.[606]

This indicator has had limited ability to monitor the overall progress of the EU because of inconsistent and incomplete data provided by Member States, which is a result of the voluntary nature of reporting, lack of common understanding of the site statuses, and differences in approaches between Member States. For example, in 2016, Poland did not provide any data on the number of sites under each contamination status, Greece provided limited information (and therefore could not be assessed for each status – see Annex 3 Table 10 of the JRC (2018) report), and incomplete information was also provided by Italy, Belgium, and Spain. For example, Belgium (Wallonia) did not provide any data for sites that need or might need remediation, sites with ongoing remediation, or sites remediated. Italy, Spain, and Belgium also provided data for some, but not all, regions (e.g. only 50% of regions in Spain).

The European Soil Observatory (EUSO) was established in 2020 to generate and disseminate harmonised EU soil data and indicators, including through working with Member States to identify national soil data.[607] The work of EUSO builds on ESDAC and focuses on data for many soil topics, including pollution. Similar to the activities conducted by the JRC and ESDAC over the last two decades, the work by EUSO relies on voluntary involvement of Member States.

Member State differences in contaminated site identification and inventories

Significant differences exist between Member States in terms of progress in the identification and definition of CSs. Where Member States have not reported on progress (e.g. to the JRC/ESDAC, EIONET), it is challenging to evaluate progress that has been made.

The differences between Member States' progress in identification of CS is approximated in the table below, based on the JRC (2018) questionnaire responses (number of sites at each status), the EEA (2022) update to this data,[608] and also data available from ESDAC from before 2016 which shows estimates for the percentage completion of investigation in each Member State and whether inventories are/were established.[609] The approximations are limited by the extent to which countries reported (described above) and the lack of information on the extent of contamination in each Member State. Furthermore, estimating the state of CS inventories is limited by the lack of information on coverage of geographic area, different site statuses, what polluting activities are used to trigger registration in the inventories (e.g. in 2006, Germany and Romania reported data based on a limited number), and on whether the inventories are maintained.

Table 5-2: Member State progress in the identification and definition of contaminated sites

Member State(s)	Estimated extent completion of CS identification	Estimated state of CS inventories
Netherlands	Completed	National inventory exists
Austria, Denmark, Sweden	Significant progress	National inventories exist
Belgium	Nearly complete in Flanders, some progress in Brussels, limited in Wallonia.	Regional inventories exist – with gaps for some regions

[605] EEA (2019) Progress in management of contaminated sites. Available at: https://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites-3 ; and EEA (2021). Management of contaminated sites in Europe. Rainer Baritz - Workshop "Contaminated Sites Management in Italy" - 03 March 2021. Available at: https://www.isprambiente.gov.it/files2021/eventi/bonifiche/ppt-baritz-national.pdf
[606] Progress in the management of contaminated sites in Europe (europa.eu)
[607] EGU General Assembly 2022, European soil observatory (EUSO) structure and perspectives. https://meetingorganizer.copernicus.org/EGU22/EGU22-5248.html
[608] EIONET questionnaire on national contaminated sites — European Environment Agency (europa.eu)
[609] Soil Contamination - ESDAC - European Commission (europa.eu) - extracted from the Excel referenced in section 2 (Sheet 5 "RemediationMedia").

Finland, Luxembourg, Lithuania	Moderate progress	National inventory exists
Germany	Moderate progress	Regional inventories exist
Hungary, Estonia, Czechia, Cyprus, Latvia	Some progress	National inventory exists
Italy	Some progress	Regional inventories exist – with gaps for some regions
Croatia	Some progress	No inventory (in 2016) – some data from specific projects
Bulgaria, Slovakia	Limited progress	National inventory exists
Malta, Slovenia, Portugal, Poland	Limited progress	Inventory planned for or in preparation in 2016
Ireland	Limited progress	National inventory exists
Romania	Limited progress	Inventory in preparation
Greece	Unknown	Inventory in preparation in 2016

It is important to note that existence of a register does not necessarily indicate better reporting by Member States. Only 8 Member States[610] reported new contaminated sites to the JRC between 2011 and 2016. Croatia was among these countries, despite not holding an official inventory. 17 Member States *with inventories* (national, regional, or local) did not report new contaminated sites between 2011 and 2016,[611] which may indicate that limited effort to identify CS was taking place during those years, despite the existence of inventories.

Furthermore, efforts vary as Member States have methodological differences in identifying sites, e.g. which contaminants are monitored, which polluting activities are recognised (as mentioned above), and the degree of effort which is made to conduct site investigations. For example, Belgium has a well-maintained register and was able to report 1,600 mercury-contaminated soils, while several other Member States reported no mercury-contaminated soils in the context of an exchange in accordance with article 15 of the Mercury Regulation.[612] The lack of mercury-contaminated soils registered is likely due to differences in the efforts made, methodologies and reporting, rather than lack of contamination, for example, high levels of mercury contamination have been identified in other countries such as Austria, Germany, and Slovenia in scientific studies but not through Member State reporting to the JRC.[613] The JRC and ESDAC estimated in 2021 that there are at least 209 mercury hotspots in Europe, including areas close to past mining activities, such as in Spain, Italy and Slovenia, and coal combustion sites, such as in the Czech Republic, Germany and Poland.[614]

Other methodological differences in Member States inventories can be observed. For example, the French inventory system is dynamic, and remediated sites are removed from the updated inventory (Basol) and transferred to a historical inventory (Basias). In Slovakia, the management of small landfills has been included under the Waste Act and, hence, those sites have been removed from the national inventory. In the Netherlands, the national register only monitors and addresses urgent sites.[615]

Number of sites needing investigation in the EU

The table below shows the number of sites reported to the JRC in 2016 with each contamination status, including corrections based on the EEA 2022 indicator update. These are underestimates as

[610] Austria, Belgium, Croatia, Estonia, Finland, Italy, Lithuania, Malta. JRC (2018) p. 41

[611] Bulgaria; Cyprus; Czechia; Denmark; France, Germany; Greece

[612] Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee Of The Regions. EU Soil Strategy for 2030 Reaping the benefits of healthy soils for people, food, nature and climate. COM/2021/699 final

[613] Ballabio, C., Jiskra, M., Osterwalder, S., Borrelli, P., Montanarella, L., & Panagos, P. (2021). A spatial assessment of mercury content in the European Union topsoil. *Science of the Total Environment*, *769*, 144755

[614] JRC, ESDAC (2021). Mercury content in the European Union topsoil. Available at: Mercury content in the European Union topsoil - ESDAC - European Commission (europa.eu).

[615] The Netherlands, Working paper for the Soil Health Law: contaminated sites

data reported were incomplete. For some site statuses, more likely estimates have been made based on the EEA update to the indicator on progress in the management of CS in Europe.[616] For some statuses, upper estimates are generated in an attempt to capture uncertainty. However, overall, these numbers should be interpreted with caution. Further elaboration of relevant site statuses is provided below.

Table 5-3: Number of sites currently at each status

Site status	Meaning of site status	Number of sites reported in 2016 across the EU-27*	Estimated number of sites across the EU-27
1a	PCS (estimated) (sites needing preliminary survey)	1,983,000	2,800,000
1b	PCS (registered) (sites needing preliminary site investigation)	1,387,000	1,900,000
2a	CS (sites needing main site investigation)	322,000	1,000,000
2b	CS (sites where main site investigation is ongoing or complete)	355,000	-
3	Site investigated but no REM needed	355,000	-
4a	CS (with unacceptable risk) – REM is needed	56,000	166,000
4b	CS (with unacceptable risk) – REM might be needed	134,000	-
5	CS (with unacceptable risk) – REM ongoing	11,000	16,000
6	Remediated site	115,000	-

It is estimated that across the EU there are 2.8 million PCSs. The true number depends on how PCSs are identified, e.g. if all potentially polluting activities currently considered in some Member States are considered, the number would be far higher.[617] Typically, PCSs go through the following stages of investigation: 1) preliminary survey; 2) preliminary investigation; 3) main site investigation. At each stage, a number of sites will be filtered out as not contaminated. In some cases where contamination is clear, the first two steps may not be needed and the site taken through to main site investigation.

It is estimated that 2.8 million sites are in need of preliminary survey of have already been investigated. Based on estimates from the EEA that 36% of PCSs are confirmed as CSs,[618] assumed number of sites needing main site investigation is 1 million. Assuming that preliminary surveys and preliminary investigations each filter out the same proportion of sites, 1.9 million sites were assumed that need preliminary investigation.

Efforts to investigate contaminated sites under the baseline

Between 2006 and 2011, an average of 16,500 PCSs were registered in national inventories. This value increased to 25,900 between 2011 and 2016. The number of preliminary and main site investigations undertaken each year is unknown (because of inconsistent reporting between years). It is assumed to be of the order of several or tens of thousands. It is considered likely that without intervention, efforts would decrease over time, due to the following reasons:

- Member States currently making good progress in identifying sites are likely to reduce efforts over time, as the number of sites needing investigation reduces.
- Member States currently failing to implement investigation measures would generally not be expected to increase efforts to investigate sites, due to general lack of requirements in

[616] https://www.eea.europa.eu/ims/progress-in-the-management-of

[617] In communication with the EEA, it was discussed that there could be 5 million suspected PCSs if the scope for polluting activities is broad. 2.8 million is considered more likely than this value.

[618] EIONET LSI003 Site Status Nov2022.pdf (provided by EEA)

existing national and EU laws. If current efforts of these countries continue, a large number of sites would not be identified over the time horizon.

Across the EU, both public authorities and the private sector bear costs associated with the remediation of contaminated soils.[619] Distribution of expenditure varies substantially between Member States, but on average, more than **43% of costs are borne by public authorities**[620] (mostly national authorities, but also the EU where funding has been provided to some Member States). The remainder is left for the private sector. Importantly, this figure relates to investigation and remediation (combined), however, as no estimate specifically for investigation was identified, this will be used as a proxy to estimate expenditure on investigation associated with this building block.

5.2 DEF - Option 2: CS identified using risk-based approach defined by Member States

5.2.1 Description of option and requirements for implementation

The following measures are considered:

1. Obligation for Member States to identify all PCS/CS, and to publish these in a **public register**. Member States to define the approach for registration.
2. Obligation for Member States to define triggers for soil investigation, and based on these triggers, identify all CSs *that may pose a risk* and all CSs *with unacceptable risks requiring risk reduction measures*. Member States shall publish these lists in a **public register**.

Option 2 differs to Options 3 and 4 as it provides **Member States with responsibility to define risk assessment methods and acceptability thresholds for identifying contaminated sites**, in comparison to Options 3 and 4 which require the EU to guide the approach to some extent. Option 2 would aim to give Member States more flexibility so that they do not have to adjust current processes to be harmonised across the EU. Identification of sites under Option 2 and 3 would be risk-based, e.g. taking into account local site conditions and background values.

In response to the OPC, there was a strong agreement across all stakeholder types that there should be legal obligations for Member States to identify contaminated sites that pose a significant risk to human health and the environment. 89% of all respondents 'totally agreed' this obligation should be put in place, with a further 8% 'somewhat agreeing'. Furthermore, 'totally agree' was the most frequent response across all stakeholder types. There was also strong agreement that the information and environmental data from a registry of contaminated sites be publicly available – in this case 85% 'totally agreed' with 10% 'somewhat agree'. 'Totally agree' was the most common response across the majority of stakeholder types with the exception of business associations and trade unions, in which case 'somewhat agree' was most common.

5.2.2 Assessment of impacts

The most significant impacts from this building block are the indirect impacts related to remediation that would be facilitated by the improved state of knowledge on the state of local soil contamination across the EU. These impacts are described in building block 5, but are fully dependent on the measures under this building block 4, and should not be considered in isolation. The below sub-

[619] JRC (2018) Status of local soil contamination in Europe p. 60
[620] JRC (2018) Status of local soil contamination in Europe p. 78

sections describe only the direct impacts related to identification, registration, investigation and assessment of (potentially) contaminated sites.

Economic – option 2

The key direct negative economic impact associated with this building block (relevant to all options) would be the costs of investigations to identify CSs. Investigations take place at different stages depending on the contamination status of a site. Preliminary surveys are first undertaken to determine whether suspected PCSs qualify as PCSs. If the presence of a polluting activity is confirmed, preliminary site investigations are undertaken to determine whether the PCS qualifies as a CS (i.e. soil sampling confirms or disproves the existence of contamination). CSs will then undergo main site investigations (soil sampling, sometimes groundwater sampling, and analysis) to determine the level of risk presented by a site to human health and the environment.

The following approximations are made:

1) €500 average costs for a preliminary survey (based on a lack of specific estimates, but assumed low cost as preliminary surveys are usually desk-based).
2) €4,000 average costs for a preliminary investigation (based on reporting that in Flanders, the average cost for preliminary investigation is €4,500,[621] while site investigations are typically marketed online at €1,750 – €5,250.)[622]
3) €15,000 average costs for a main site investigation (based on reporting that in Flanders, the average cost of main site investigation has been reported as €15,000).[623] Although more costly site investigations have been reported (e.g. up to €5 million),[624] the majority (74%) of investigations fall between €500 and €50,000. Furthermore, more costly investigations are likely to be beyond the scope of this assessment (e.g. the UK Homes & Communities Agency reported site investigation costs of tens to hundreds of thousands of euros, however, the scope included geotechnical and ordnance surveys in addition to contamination assessment).[625] Higher costs may also reflect parameters such as radioactive contaminated land investigation (beyond the scope) and may reflect large site investigations (whereas the majority of sites needing remediation in the EU are thought to be small).[626]

Estimates for expected investigation costs under building block 4 are made in the table below.

Table 5-4: Expected total costs of site investigations under building block 4 (including costs existing under the baseline) (2013 prices)

Investigation type	Number of sites expected to need investigation	Assumed cost of investigation per site	Assumed total cost of investigation
Preliminary survey	2.8 million	€500	€1.4 billion
Preliminary investigation	1.9 million	€4,000	€7.6 billion
Main site investigation	1 million	€15,000	€15 billion

[621] EY (2013) Evaluation of expenditure and jobs for addressing soil contamination in Member States, p. 135
[622] Based on a web review of available services (searched 12 December 2022). For example: https://www.castledineenvironmental.co.uk/costs; https://groundconsultants.co.uk/faq/
[623] EY (2013) Evaluation of expenditure and jobs for addressing soil contamination in Member States, p. 135
[624] JRC (2014) Progress in the management of contaminated sites
[625] UK government, Homes & Communities Agency (2015). Guidance on dereliction, demolition and remediation costs. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/414378/HCA_Remediation_Cost_Guidance_2015.pdf
[626] EY (2013) Evaluation of expenditure and jobs for addressing soil contamination in Member States, p. 79

TOTAL	€24 billion

Total costs cannot be quantitatively compared to the baseline with certainty, however, speculating a potential time horizon for this intervention of 15 years, the intervention could result in average annual costs of €1.6 billion (1.9 billion euro annually or a total of 29 billion in 2023 prices), reflecting 185,000 preliminary surveys, 125,000 preliminary investigations, and 65,000 main site investigations. In comparison, it was assumed that under the baseline several or tens of thousands of sites would undergo each stage of investigation.

These costs would affect only specific Member States, i.e. where limited progress has been made (see above section on Member State differences and below on distribution of effects).

As described in the baseline, currently, on average, public authorities would bear 43% of these costs and the private sector would bear 57%, however, the divide currently varies substantially between Member States. Based on responses to the 2011/2012 and 2016 questionnaires (JRC, 2014; JRC, 2018), 100% of contaminated site management in Czechia and Portugal was funded by national/regional authorities. In Estonia, more than 60% was funded by national/regional authorities. Six Member States received significant EU funding for contaminated site management (funding 70% of CS management in Portugal, nearly 50% in Latvia, 40% in Slovakia, 20% in Belgium (Wallonia), and <20% in Estonia and France). Finland, Belgium (Flanders), Cyprus, and France were the only Member States who responded that the private sector pays for the majority of CS management.[627] The data was not disaggregated by investigation and remediation. The varied proportions are generally due to differences in national laws and the extent to which they implement the Polluter Pays Principle.

The measures under this building block would **encourage costs to be borne by authorities. Member States would be legally obliged to identify PCSs/CSs**, and therefore may not have a choice when the polluter is unidentifiable, therefore the 43:57 divide described above might shift.

In addition to investigating sites, ***administrative burden*** would be incurred to maintain the database / IT infrastructure upon which the inventories are based. These costs are expected to be lower than the costs of investigations, for example, in 2018, Sweden had a budget of €22 million for investigations and €230,000 for maintaining the national CS inventory.[628] Member States will incur an administrative burden, e.g. staff costs, development of IT infrastructure or a website – but these costs will be substantially less than the cost of investigation. Businesses might experience additional administration and communication due to the identification, registration and identification of contaminated sites. This administrative burden is estimated roughly at 1% of the investigation cost (1% of 1,6 billion euro (2013 prices) annually).

Administrative burden of EU authorities may be impacted, as authorities would be expected to report on the EU status of local soil contamination. Additional costs could be incurred as this building block could result in a greater volume of data for authorities to gather, analyse, and report. On the other hand, obligatory reporting by Member States in public registers could reduce the burden of EU authorities requesting data. More complete data may also facilitate data processing as less extrapolation would be required.

[627] JRC (2018) Status of local soil contamination in Europe, p. 60
[628] JRC (2018) Status of local soil contamination in Europe, p. 64

Despite the large magnitude of costs described above, the indirect economic benefits from remediation, facilitated by the identification of CSs, are expected to be high. These are expected in the form of ***avoided human health costs, regeneration of the economic value of land, and ecosystem services*** (described under building block 5).

Further economic benefits would be generated as requiring PCS/CS identification in all Member States would work towards a ***level playing field*** between Member States in terms of the amount of effort which is being made to identify PCSs and CSs. Currently, efforts vary substantially between Member States. Across all site statuses, the Netherlands, Germany, Belgium, and Sweden have registered the most sites (>100,000 each), while other countries reported very low numbers of sites (e.g. 55 total in Bulgaria, 66 in Ireland, and 98 in Cyprus). Based on the approximated site investigation cost of €20,000, this translates to an enormous difference in spending between Member States. For example, 40,000 sites under investigation in Belgium in 2016 = €800 million, while three under investigation in Portugal = €60,000, and one under investigation in Slovenia = €20,000.

Specific to Option 2, there may be costs to Member States to establish and apply a methodology or procedure for risk assessment of PCSs and CSs, and to define the risk level for human health and the environment that is considered (un)acceptable. However, these costs are expected to be negligible.

Environmental –option 2

The JRC (2018) highlighted that comprehensive inventories have played a critical role in facilitating the identification of soil contamination over the last two decades in certain Member States where legal instruments have been put in place.[629] This indicates that this building block would indirectly benefit the environment through facilitating and amplifying the environmental benefits from remediation under building block 5. Remediation and risk reduction measures of all sites where contamination presents an unacceptable risk to human health and the environment cannot take place without a knowledge base describing where these sites are. Ultimately, the indirect impacts would be a **decreased presence of toxic chemicals in the environment**, and consequential positive impacts on species, populations, and biodiversity, as well as ecosystem services. These impacts could be enhanced by the deterrence of potential polluters, preventing future additional contamination.

Social – option 2

Stakeholders across all categories are supportive that Member States should be obliged to keep publicly available inventories for (potentially) contaminated sites. This building block 4, alongside the remediation building block 5, would therefore have positive social impacts for EU citizens and other stakeholders through reassurance that actions to address soil contamination (and protect human health and the environment) are being taken. As this building block encourages application of the Polluter Pays Principle, it would improve societal fairness and good administration. On the other hand, it could lead to distress among communities and landowners suddenly confronted with the declaration of their properties as polluted sites.

Requirements to identify contaminated sites would bring direct long-term benefits through job creation and ***employment*** in contaminated site investigation (e.g., environmental / earth scientists and consultants). EY (2013) estimated that the introduction of an EU legal framework for soil would treble the size of the investigation and remediation market in terms of number of jobs and increase

[629] JRC (2018) pp. 43

turnover from €2.75 billion per year to €4.6 billion per year, with a peak 15 years after implementation.[630] These values are based on different assumptions (e.g. a lower starting value for the EU remediation market and a higher number of PCSs) and so they are not directly applicable here, although they demonstrate that the boost to employment in this sector would be substantial. Furthermore, a study in Denmark found, using a specially created model, that each time 100 million DKK (about €13.5 million) of public money is invested in contaminated sites, 230 new jobs are to be expected.

Based on the additional costs estimated to investigate CS, it is estimated that this could lead to a direct, additional employment effect of around 26,200 FTEs on an ongoing basis. There will also be additional indirect and induced employment effects as the impacts ripple through the economy. Although more uncertain than the estimate of direct effects, an estimate of the total employment effects is around 35,200 additional FTE jobs on an ongoing basis. Further detail of the approach and results to estimating employment effects is presented in the section on 'quantification on employment impacts'. Although this benefit would be incurred to some degree through this building block alone (e.g. jobs for investigation consultants), the full benefit of job creation is co-dependent on both this building block and the remediation building block.

Furthermore, better identification of contaminated sites could encourage broader changes in land use practices to make them more sustainable and hence contribute more broadly to ***sustainable development***. Overall, this option would lead to a reduction of toxic chemicals in the environment, contributing to good health and well-being (SDG 3), sustainable consumption and production (SDG 12) and life on land (SDG 15).
Indirectly, the measures under this option would facilitate interventions to reduce contamination of land across the EU which would have a number of impacts associated with them.

5.2.3 Distribution of effects

Since the current efforts to identify and report on contaminated sites vary substantially between Member States, the impacts of this building block would be distributed unevenly across the EU. Expected differences between Member States (based on **Error! Reference source not found.**) are described below and apply to both positive impacts and costs.

Based on available information the following would be expected:

- No significant impacts on the Netherlands (other than indirect benefits from moving towards a level playing field across the EU)
- Potentially minimal impacts on Austria, Denmark, Sweden
- Likely low impacts on Belgium (specifically, in the Wallonia and Brussels regions), Finland, France, Spain, Luxembourg, Lithuania, Germany
- Medium impacts on Hungary, Estonia, Czechia, Cyprus, Latvia, Italy, Croatia
- Highest impacts on Bulgaria, Slovakia, Malta, Slovenia, Portugal, Poland, Ireland, Romania, and Greece.

Costs will fall initially on Member State national and regional authorities as this is where the obligation is placed to identify all PCSs and CSs. That said, there is some uncertainty regarding which stakeholders will bear the costs as this depends on the method of implementation in different Member States.

[630] EY (2013). Evaluation of expenditure and jobs for addressing soil contamination in Member States

There may also be a trend in the location of stakeholders affected. Many (but not all) CS are likely to be located in urban or semi-urban locations. As such, where the costs of identification (and in particular risk assessment) are shared with private actors, many will fall in the first instance in these areas. That said, in many cases a single CS will be one site in a wider portfolio, and the costs will accrue to the over-arching business owner, who may spread these costs across its portfolio.

5.2.4 Risks for implementation

The main risk is that (relative to Options 3 and 4) Option 2 does not include provisions for the EU to guide Member States in their approaches to assess contaminated sites, aside from the provision that the methods should be risk-based. This would reduce the intervention's contribution to a level playing field and reduce the indirect human health and environmental benefits as some CSs with unacceptable risks might not be identified.

5.2.5 Links /synergies

Measures related to the definition, identification, investigation and risk assessment of contaminated sites are intended to facilitate and direct the other measures, therefore enhancing their benefits. In particular, the measures are essential as a prerequisite to facilitate subsequent remediation. Measures for defining and identifying contaminated sites and should be considered in harmony to the measures defining conditions for good health of soil (building block 1).

Identifying contaminated sites is coherent with and complementary to existing EU policies and legislations and the global ambition to identify and assess sites contaminated with mercury, as set out by the Minamata Convention.

Some of the 'risk activities' susceptible of contaminating a site are already recognised under the Industrial Emissions Directive and Environmental Liability Directive, which could therefore support Member States in achieving identification of PCSs under this building block. No incoherencies with existing EU legislation were identified. On the contrary, indirect positive contributions to the objectives of broader environmental legislation, such as the Water Framework Directive and Environmental Quality Standards Directive, may be expected. The intervention should be considered alongside the Chemicals Strategy for Sustainability 'one substance, one assessment' initiative which aims to co-ordinate the risk assessments conducted by different EU agencies to avoid duplicated efforts for risk assessment, and therefore may help Member States to risk assess PCSs/CSs. Furthermore, the forthcoming EU Repository of Health Based Limit Values which aims to promote the harmonisation of human and environmental health-based limit values among risk assessment actors could support risk assessments.

Importantly, it should be considered how the public registers to be produced and maintained by Member States would fit with the existing EU-wide platforms and IT infrastructure for soil monitoring (INSPIRE, ESDAC and ESDB).

5.2.6 Summary assessment against indicators

Significant efforts are being made under the baseline to identify PCSs/CSs and to list these in inventories, however, the distribution across Europe is uneven. Member States which currently undertake little effort to identify PCSs/CSs will face significant costs, but the magnitude is uncertain. Over time, the economic impacts would transition to positive impacts through avoided health and environmental costs through the facilitation of remediation. The facilitation of remediation measures is also expected to lead to positive social impacts (protection of health) and environmental impacts (protection of the environment).

Table 5-5: Overview of impacts of option 2

Effectiveness	**Impact on soil health**	(+)	No direct impact but, by defining, identifying and risk-profiling PCS and CS, option is a prerequisite for remediation activities on CS under the REM building block. How the risks of CS are assessed under DEF will determine to a great extent the ambition, benefits and costs of the REM building block.
	Information, data and common governance on soil health and management	+++	Obligation to register systematically potentially contaminated or suspected sites, and subsequently, to confirm the presence or absence of contamination on these potentially contaminated sites. Hence option will deliver a significant improvement
	Transition to sustainable soil management and restoration	(+)	No direct impact, but presents necessary foundation to remediation action
Efficiency	**Benefits**	+++	Improvement in data, information and governance key benefit of the option
	Adjustment costs	---	Significant average investigation cost of 1,9 billion euro (2023 prices) annually. Part of this amount is part of the baseline.
	Administrative burden	---	Administration and communication due to the identification, registration and investigation of contaminated sites (> EUR 5m pa).
	Distribution of costs and benefits	-	Effect uncertain, but different Member States have different CS hence costs likely to fall unevenly across Member States. Additional burden greater for Member States will more limited identification systems to date.
Coherence		+/-	Option less coherent will all options under REM
Risks for implementation		---	Given direct link to remediation ambition under REM, flexibility provided presents a significant risk that some Member States could apply less effective investigation techniques, leading to a lower than effective level of remediation activity in some Member States, and an uneven playing field across the EU

5.2.7 Opinions of stakeholders

Opinions received on the obligation to identify contaminated sites and make a public inventory are presented below, for each EU MS and further major stakeholder types. Information was extracted from written feedback received from MS and other stakeholders.[631] EU MS generally agreed on MS being responsible for this task and applying a risk-based approach. Some saw the responsibility with project promotors. The MS also supported the public availability of the generated data, however, given that the consideration of privacy rights will be assured.

Table 5-6: Overview of stakeholder input on DEF

	Obligation to identify contaminated sites and make a public inventory
Austria	• Clarification regarding the relation of the terms like “soil”, “healthy soil”, “site”, and “contaminated site” vs. “unhealthy soil” required;

[631] Note that opinions from OPC position papers for civil society and research and academia stakeholders are not synthesized here. Please see the synthesis of stakeholder consultations for more information on the views of these stakeholders.

	• Defining a core set of soil contaminants could be a helpful starting point, yet defining specific values for these contaminants is not suitable; • Subsidiarity principle to be applied; • Binding rules for agricultural and forestry soils not deemed necessary; • Knowledge exchange on risk assessment methodologies supported; • Data is and should be made available.
Belgium	• Stress that 'groundwater' should be included within the definition, clarification on 'sites', 'confirmed presence', 'dangerous substances' should be provided; • Support the inclusion of a non-exhaustive list of soil contaminants; • If defining common specific values per contaminant cannot be achieved, the SHL should should provide at least the method enabling each MS to establish its own specific set of values; • Data should be publicly available.
Bulgaria	No answer provided
Croatia	No answer provided
Cyprus	No answer provided
Czech Republic	No answer provided
Denmark	No answer provided
Estonia	No answer provided
Finland	• Groundwater' should be included within the definition offered; • Risk-based approach supported (if contamination is suspected); • Approaches on contaminated sites should be decided by MS; • Data is public but not freely available; • A EU-level data collection can cause too much administrative effort.
France	• A separation between groundwater and soil should be avoided, groundwater must be included in the management of polluted soils; • Diffuse pollution prevention should be included within the scope of the definition in order to tackle the range of pressures and threats posed; • Risk-based approach considering land use supported, soil contaminant lists should be avoided; • Soil testing can be triggered by land use changes. Responsible party still to be defined but so far mostly the project promoter; • Data is already publicly available in France.
Germany	• Definition should include ionizing radiation; • Risk-based approach supported (if contamination is suspected); • Data to be publicly available, considering privacy guidelines (potentially distinguish between identified contaminated sites and suspected contaminated sites).
Greece	No answer provided
Hungary	No answer provided
Ireland	• The definition should consider the inclusion of 'diffuse pollution'; • A uniform definition of 'unhealthy' should be established, triggering assessments, or 'unhealthy' should be defined by MS; • Risk-based approach supported;

	• Support the sharing of contaminated site data to the public; • Operators of risk activities should be forced to sample.
Italy	• Request a definition of 'site' to be provided; • Risk-based approach applied and supported, yet clarification on the relationship between risk-based management of contaminated sites and soil health needs to provided; • Request that 'groundwater' be included within the definition of contaminated sites, whereas 'diffuse pollution' should be excluded; • Support the establishment of 'minimum list' of 'priority substances'; • Exchange of information should be encouraged by the Commission; • Data should be publicly accessible.
Latvia	No answer provided
Lithuania	No answer provided
Luxembourg	• "Site" and "significant risk" in the definition need to be clarified, 'groundwater' should be included; • If responsibility given to MS, they also need tools and budget to do so; • Data should be publicly accessible. •
Malta	No answer provided
Netherlands	• Groundwater contamination caused by point sources should be included in the definition; • Risk-based approach supported; • Data should be publicly available.
Poland	• Clarification on the definition of 'sites'; • Do not support the unification of limit values for contaminants; • Registration of (potentially) contaminated sites should be stream lined across the MS; • Data should be publicly available (Considering privacy guidelines).
Portugal	• Support the establishment of a core set of parameters (soil contaminants with specific / uniform values) for different land uses that will contribute to the definition of the Soil Health status of the site • Data should be publicly available (Considering privacy guidelines).
Romania	• 'Groundwater' should be taken into account; • In favour of establishing a list of pollutants/contaminants at EU level, with flexibility in setting limit values at national level; • Data should be publicly available.
Slovakia	No answer provided
Slovenia	No answer provided
Spain	• Generally, data should be publicly available but should consider privacy guidelines and impact on market value.
Sweden	• Definition needs to clarify what is meant by "significant" risk, and whether this definition would require a risk assessment to be carried out before the site is classified as contaminated, clarification on 'site' required; • Does not support the use of common trigger values; • Data should be publicly available, but sites owned by defence authorities, e.g., should be excluded from public reporting obligation;

	• Obligatory risk assessments need further definitions to avoid unnecessary work. •
Other public authority	• Risk-based approach supported, focus on severe problems.[632]
Farmers	No answer provided
Foresters	No answer provided
Land owners / land managers	No answer provided
Industry (businesses and business associations)	• Risk-based approach for soils investigation and remediation measures supported to ensure economic feasibility. n=3[633] • Science and evidence-based approach preferred to precautious principle.[634]
Civil society (NGOs)	No answer provided
Research and Academia	• Risk-based approach supported; Investigations triggered when change of land use.[635]

5.3 DEF – Option 3: CS identified using risk-based approach with common principles defined at EU-level

5.3.1 Description of option and requirements for implementation

Instead of allowing Member States to choose which assessment method they use to identify CSs and sites requiring remediation, the EU would define the common principles of the assessment method, resulting in more convergence of risk assessment methodologies[636] across the EU and more knowledge exchange between Member States, while still giving Member States full flexibility on the degree of risk they are prepared to accept. Furthermore, while Option 2 would introduce legal provisions to make reporting *mandatory* (see also building block on monitoring), Option 3 would introduce legal provisions to improve *uniformity* of reporting to some degree through common principles.

Common principles could reflect "guidance for use" elements recommended for flexible risk assessment tools.[637] For example, guidance on different input parameters, optional risk assessment tools, boundary conditions for the applicability of risk assessment tools. Swarties et al. / RIVM

[632] Common Forum
[633] Cefic, Concawe, NICOLE
[634] NICOLE
[635] INRAE
[636] Risk assessment methodologies typically utilise standardised risk assessment tools or flexible risk assessment tools. Standardised risk assessment tools are not tailored to specific Member States/ sites and may include fixed quantitative parameters, e.g. daily inhalation rates, tolerable exposure value, species sensitivity distributions, or a database with contaminant characteristics. Flexible risk assessment tools allow geographical, cultural, and political differences to be accounted for. For example, vapour intrusion models (dependent on soil type and groundwater depth) and time-activity patterns are considered flexible risk assessment tools.
[637] Swartjes, F. A., Cornelis, C., Wcislo, E., Muller, D., Hazebrouck, B., Jones, C., & Nathanail, C. P. (2009). Towards consistency in Risk assessment tools for contaminated sites management in the EU. p 17 and 18. RIVM letter report 711701091.

(2009) recommends a common (harmonised) toolbox for improved flexible risk assessment approaches in Europe.

The EEA (2022) report on indicators and thresholds for soil health assessments includes a chapter on soil pollution and describes the current knowledge base for soil screening values in relation to risk assessment of CSs.[638] The recommendations for convergence of risk-based land management procedures could be valuable to inform the common principles set out by the Commission under this building block, for example Table 5-10 of the report sets out components for a potential European toolbox, related to human health risk assessment (standardised tools including daily inhalation rates, tolerable exposures etc.), ecological risk assessment (standardised tools including species sensitivity distributions, contaminant characteristics such as water solubility, vapour pressure, partition coefficients), endpoint specific risk assessment (standardised tools including EU-wide soil pore water concentration), and country- and site-specific considerations (flexible tools with components for geographic conditions, history of land management, national legal conditions).

The "common principles" *could* include an indicative or mandatory minimum list of pollutants, the application of the fit for use principle, and common risk assessment methodologies. The minimum list would represent a non-exhaustive list of critical pollutants which would have to be constantly revised in the Directive based on emerging pollutants detected, similar to the watch list provisions of the Water Framework Directive.

Several stakeholders (Member States, industry associations, companies) reported in consultation that common principles should require risk assessments to be site-specific and risk-based. A mining company also suggested that assessments should take into account the respective or intended land use. Member States would not be restricted to the analysis of certain substances and would be able to define their own limit values.

5.3.2 Assessment of impacts

Economic – Option 3

Costs to Member State authorities (***Public budgets and authorities***) would be expected in a similar way to Option 2. For some Member States, a set of common principles devised by the EU would provide additional guidance which would make it easier to develop assessment methods at Member State level, reducing the administrative burden (relative to Option 2). On the other hand, if Member States are forced to revise the methods and principles currently implemented to assess contaminated sites, additional costs could be incurred to transition to the common arrangements. However, given that the nature of common principles is uncertain, it is unclear whether, and if so which, Member States would have to revise existing methods. For example, respondents to the JRC (2018) questionnaire generally already use site-specific risk assessment methods.[639] Latvia and Lithuania reported using threshold values rather than site-specific risk assessment, while most Member States mentioned both.

Although costs may be incurred to develop guidelines for common principles, EU authorities would benefit from this option to a greater extent than Option 2 because as well as introducing mandatory and regular reporting of soil data by Member States, this option would have added value of

[638] EEA (2022) Soil monitoring in Europe Indicators and thresholds for soil quality assessments
[639] JRC (2018) P. 50 – 52.

improving consistency between Member State data. Aligned assessment methods would make it easier to amalgamate data from Member States to discern overall EU trends in soil health, e.g. in analysis undertaken by the JRC.

Environmental – Option 3

The objectives of the restoration and remediation building block could not be achieved without the identification of contaminated sites. Common principles for risk assessment could improve the quality of site investigations undertaken across Member States, therefore improving extent to which CSs are identified and remediated, and therefore the extent to which the environment is protected. However, the realisation of this impact is dependent on the nature of common principles introduced.

Social – Option 3

The social impacts of this option are expected to be the same as those explored under the Option 2, with potentially more positive environmental and health benefits as identification of CSs could be improved (facilitating remediation of more CSs). If the common principles improve the quality of risk assessments undertaken across Member States, they could increase the accuracy of investigation results, e.g. reduce the number of false results, which could otherwise result in insufficient or disproportionate efforts to remediate in certain cases.

5.3.3 Distribution of effects

As noted in the description of economic impacts on public authorities, current efforts activities to identify and report on contaminated sites vary substantially between Member States, and therefore impacts of this building block option would be distributed unevenly across the EU. Some costs will fall on the EU, which will have to define the common principles of the assessment method of the risk level. The majority of costs will likely fall on Member State national and regional authorities which have already implemented an assessment method, and which will have to adapt to new common principles (although it is unclear what extent of adaptation would be required). On the other hand, Member States without any previous risk assessment method will benefit (compared to Option 2), as they will have to follow EU common principles instead of producing them individually.

5.3.4 Risks for implementation

Generally, Member States that risk assessment methods should be left to Member States to avoid duplication of efforts. These stakeholders expanded that “principles” are not a good starting point for risk assessment methodologies, implying that the option is too broad to bring added value to site investigations. This view was likely due to the lack of specific information on what common principles could look like, and therefore concern that principles could be too stringent. As such, this risk could possibly be mitigated by achieving a good balance of specificity and flexibility in defining the common principles. Stakeholders suggested that common principles should be discussed after establishment of the Soil Health Law / after there is a clearer view of what principles could look like. There was also a suggestion that these common principles could be established as general guidance for Member States to follow voluntarily.

Furthermore, this option still entails a risk that there would be a lack of harmonisation of investigation approaches across the EU, as Member States will define the acceptability thresholds of the risk to identify a CS, and a site requiring remediation. Overall, the common principles would reduce this risk significantly in comparison to Option 2.

5.3.5 *Links /synergies*

The links/synergies under this option are considered analogous to option 2, however, there may be some incoherencies with national legislation if certain Member States are required to reformulate existing risk assessment methodologies to adhere to the common principles set out by the EU under this building block.

5.3.6 *Summary assessment against indicators*

Option 3 is not substantially different to option 2, although may result in better effectiveness and efficiency as it could improve the identification and investigation of CSs in Europe through common principles. This would facilitate more targeted remediation, therefore improving protection of health and the environment, while potentially leading to more economic costs for investigation and remediation, but more economic benefits from ecosystem services and regeneration of land value.

Table 5-7: Overview of impacts of option 3

Effectiveness	**Impact on soil health**	(+)	No direct impact but, by defining, identifying and risk-profiling PCS and CS, option is a prerequisite for remediation activities on CS under the REM building block. How the risks of CS are assessed under DEF will determine to a great extent the ambition, benefits and costs of the REM building block.
	Information, data and common governance on soil health and management	+++	Obligation to register systematically potentially contaminated or suspected sites, and subsequently, to confirm the presence or absence of contamination on these potentially contaminated sites. Hence option will deliver a significant improvement
	Transition to sustainable soil management and restoration	(+)	No direct impact, but presents necessary foundation to remediation action
Efficiency	**Benefits**	+++	Improvement in data, information and governance key benefit of the option
	Adjustment costs	---	Significant average investigation cost of 1,9 billion euro (2023 prices) annually. Part of this amount is part of the baseline.
	Administrative burden	---	Administration and communication due to the identification, registration and investigation of contaminated sites (> EUR 5m pa).
	Distribution of costs and benefits	-	Effect uncertain, but different Member States have different CS hence costs likely to fall unevenly across Member States
Coherence		+	Option fairly coherent will all options under REM
Risks to implementation		--	Some risk of variability across Member States, but lower than Option 2 given application of common principles. Lower risk of driving inefficient remediation activity relative to Option 4 as some flexibility to reflect local parameters retained.

5.4 DEF - Option 4: CS identified following non-risk based approach with common EU limit values

5.4.1 *Description of option and requirements for implementation*

This option would require the EU to define specific limit values for a specific list of contaminants that indicate (1) a contaminated site, and (2) a site requiring remediation. Consequently, site-specific risk assessment methodologies and risk acceptability thresholds established by Member States would be replaced by a common list of soil screening values, i.e. generic quality standards that are used to assess land contamination.[640] This option would result in a single method to identify contaminated sites across the EU (as opposed to giving Member States more flexibility in assessment methods applied as under Options 2 and 3 above). This would ensure that Member States' data on soil contamination is provided in the most harmonised and comparable format and therefore can be combined to allow analysis of EU-wide trends in contaminated soils, therefore minimising the current challenges posed by inconsistent data across Member States.

5.4.2 Assessment of impacts

Economic – Option 4

EU authorities may face reduced ***administrative burden*** as monitoring progress towards the objectives of this intervention would be facilitated by comprehensive and consistent reporting of Member, facilitating simpler data processing, e.g. by the JRC/EEA in developing indicators/assessments in the progress of CS management. However, some resources would be spent devising screening values.

The key advantages of screening values are the speed and ease of application, the clarity for polluters and regulators, the comparability and transparency and the easiness of understanding by non-specialist stakeholders. These advantages would lower economic costs for stakeholders undertaking investigations (national/regional authorities, contractors, landowners, and operators of polluting activities) as costs per investigation would be lower.[641]

In 2011, 50% of EEA-39 countries used site-specific risk assessment methods, while 15% used screening values. This indicates that economic costs would likely be faced to a greater degree than Option 2 and Option 3 as more Member States would be required to change their risk assessment approach.[642] Furthermore, the shift to investigations based on threshold values for a defined list of contaminants could increase costs as other risk-based considerations could not be used to highlight where sites have lower risks and therefore do not need remediation (e.g. contained sites or sites where the soil type buffers contaminants). This could lead to more remediation costs. On the other hand, it could fail to identify some CSs as not all contaminants may be covered by the harmonised EU limit values. This could be the case given that emerging contaminants may arise in individual Member States and therefore not be picked up as an EU-wide problem.

Environmental – Option 4

More positive indirect impacts could be incurred as having a common system for identifying contaminated sites would save Member States the challenge of devising a risk-based assessment methodology which could delay them in taking action. The overall difference in impact between Option 2 and 3 is difficult to predict, but could likely lead to more positive impacts in the short-term (due to faster identification of CSs and therefore faster remediation) but less positive impacts in the long-term (due to oversight of some CSs because of lack of site-specific considerations). However,

[640] Provoost, J., Reijnders, L., Swartjes, F., Bronders, J., Carlon, C., D'Alessandro, M., & Cornelis, C. (2008). Parameters causing variation between soil screening values and the effect of harmonization. Journal of Soils and Sediments, 8(5), p. 2.
[641] Provoost, J., Reijnders, L., Swartjes, F., Bronders, J., Carlon, C., D'Alessandro, M., & Cornelis, C. (2008). Parameters causing variation between soil screening values and the effect of harmonization. Journal of Soils and Sediments, 8(5), p. 11.
[642] https://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites-3/assessment/view

even in the short term, there could be delays due to the challenges on agreeing common soil screening values.

Social – Option 4

The social impacts of this option are expected to be the same as those explored under Option 2. As described above in an environmental context, it is possible that this option could facilitate faster remediation, and/or result in the oversight of some sites, which could influence the scale of health benefits.

5.4.3 Distribution of effects

As noted in the description of economic impacts on public authorities, current efforts activities to identify and report on contaminated sites vary substantially between Member States, and therefore impacts of this building block option would be distributed unevenly across the EU. Greater costs under this option will fall on the EU, which will have to define the investigation methods and the risk level deemed acceptable. In terms of distribution between Member States, the majority of costs will likely fall on national and regional authorities which have already implemented an assessment method, and which will have to adapt to new methods. This differs to options 2 and 3 where the majority of costs fall on those Member States who have not yet defined identification methods for CSs.

5.4.4 Risks for implementation

There is a significant risk under this option that devising common screening values for a standardised risk assessment method across the EU may not be feasible due to differences between geographic factors across Member States. The JRC (2018) notes that "*due to the existence of a wide variety of soil types, land uses, depths of groundwater tables and site and building characteristics, the use of screening values alone might not be appropriate to assess the problem in an efficient and economically viable manner.*" For example, soil type can influence the ability of the soil to buffer contaminants,[643] therefore screening values applicable to one soil type may be over-conservative for another soil type, leading to disproportionate efforts to remediate.

Currently, there is large variability among Member States in soil screening values, which was attributed by Provoost et al. (2008) to five factors:[644]

- Geographical and biological, connected to Europe's environmental variability in its regional and physical factors.
- Socio-cultural, connected to Europe's variability of social behaviours and land use affecting the potential exposure of receptors to soil contaminants
- Regulatory, connected to regulatory requirements, namely constitutional aspects or complementarities with other existing laws
- Political, connected to the prioritization of environmental and economic values, as done by policy makers and regulators
- Scientific, connected with arguments of competing scientific views.

[643] Kicińska, A., Pomykała, R., & Izquierdo-Diaz, M. (2022). Changes in soil pH and mobility of heavy metals in contaminated soils. *European Journal of Soil Science*, *73*(1), e13203.https://doi.org/10.1111/ejss.13203

[644] Provoost, J., Reijnders, L., Swartjes, F., Bronders, J., Carlon, C., D'Alessandro, M., & Cornelis, C. (2008). Parameters causing variation between soil screening values and the effect of harmonization. Journal of Soils and Sediments, 8(5), p. 24.

The EEA (2022) note that screening values differ due to the following methodological considerations: endpoint targeted (concentration in human health, ecosystem, wildlife, animal products, crops, groundwater, drinking water, surface water); exposure unit (potentially affected fraction; tolerable daily intake, excess cancer risk); assumptions in the model; and influence of climate, land use, and variability of the soil.[645] A major limitation is that crucial site specifications cannot be included.[646]

Furthermore, screening values may produce a misleading feeling of certainty and confidence. To manage this risk, there must be conservative assumptions that overestimate the risk on many occasions.

There is a strong preference amongst many stakeholders for a risk-based approach, given the type and extent of contamination, and risk of detrimental impacts can vary depending on the nature of the site.

5.4.5 Links /synergies

The links and synergies are comparable to option 2 described above. This option may show coherency with EU legislation for other environmental compartments as risk acceptability thresholds are currently applied in water and air legislation (Water Framework Directive and Air Quality Directive), however, nuances in the requirements for soil risk assessment must be accounted for.

5.4.6 Summary assessment against indicators

Table 5-8: Overview of impacts of option 4

Effectiveness	**Impact on soil health**	(+)	No direct impact but, by defining, identifying and risk-profiling PCS and CS, option is a prerequisite for remediation activities on CS under the REM building block. How the risks of CS are assessed under DEF will determine to a great extent the ambition, benefits and costs of the REM building block.
	Information, data and common governance on soil health and management	+++	Obligation to register systematically potentially contaminated or suspected sites, and subsequently, to confirm the presence or absence of contamination on these potentially contaminated sites. Hence option will deliver a significant improvement
	Transition to sustainable soil management and restoration	(+)	No direct impact, but presents necessary foundation to remediation action
Efficiency	**Benefits**	+++	Improvement in data, information and governance key benefit of the option
	Adjustment costs	---	Significant average investigation cost of 1,9 billion euro (2023 prices) annually. Part of this amount is part of the baseline.
	Administrative burden	---	Administration and communication due to the identification, registration and identification of contaminated sites. Costs estimated at 1% of the investigation cost (> EUR 5m pa)
	Distribution of costs and benefits	-	Effect uncertain, but different Member States have different CS hence costs likely to fall unevenly across Member States
Coherence		+	Option coherent will all options under REM
Risks for implementation		---	Standard EU-wide method does not allow flexibility to reflect the particularities of each Member State and of specific sites, which may influence risk. Could result in inefficient identification of sites

[645] EEA (2022) Soil monitoring in Europe Indicators and thresholds for soil quality assessments, p. 94

[646] Provoost, J., Reijnders, L., Swartjes, F., Bronders, J., Carlon, C., D'Alessandro, M., & Cornelis, C. (2008). Parameters causing variation between soil screening values and the effect of harmonization. Journal of Soils and Sediments, 8(5), p. 11.

		requiring remediation, and therefore disproportionate costs

6 SOIL RESTORATION AND REMEDIATION (REST/REM)

6.1 Soil restoration (REST)

6.1.1 Overview

Building block outline

This building block seeks to drive the necessary measures for the restoration and remediation of unhealthy soils. As stated in the EU Soil Strategy, the goal is that by 2050 all EU soil ecosystems are in healthy condition and thus more resilient and that protection, sustainable use and restoration of soils has become the norm. By 2050, the risk of contaminated sites should be brought and kept to acceptable levels (in line with a risk-based approach and the zero pollution ambition by 2050). Risk reduction consists of actions on or in the soil, to remove, control, contain, or reduce contaminants so that a contaminated site, taking into account its current use and approved future use, no longer poses an unacceptable risk to human health or the environment.[647]

Problem(s) that the building block tackles

This building block works towards tackling to following problems identified in the intervention logic:

- **Main problem** - Soils in the EU are unhealthy and continue to degrade.
- **Sub-problem B** – A transition to sustainable soil management and restoration is needed but not yet happening, e.g., for the unsolved legacy of contaminated sites.

For example, there is a need to improve the practices undertaken by land managers and farmers to restore and remediate soil degradation. This is due to a range of drivers:

- Principal-agent problems, e.g., tenants not incentivised not improve soil health.
- Incomplete EU framework to support restoration.
- National and EU laws do not effectively promote soil restoration.
- Lack of awareness of the importance of soil health.
- Focus on short-term benefits without taking account of future costs.
- Income-related drivers.

There are only partial EU-wide provisions for remediating contaminated sites derived from the IED (obligation to return to baseline status for the operator) and the ELD ('land damage' concept, which assigns financial responsibility to operators that have prompted land contamination that creates a significant risk for human health). While new contamination is partly prevented and addressed by wider EU legislation (e.g., the Industrial Emissions Directive, the Waste Framework Directive, and the Landfill Directive), approximately two thirds of the contamination affecting EU soils is from historic polluting activities.[648] Furthermore, illegal contamination is not addressed by current provisions as the polluters cannot be identified, which presents a significant issue, e.g. in Greece

[647] CLARINET. 2002a. Sustainable Management of Contaminated Land: An Overview, p. 128. "Contaminated Land Rehabilitation Network for Environmental Technologies" (CLARINET. Retrieved from JRC (2018), p. 56.
[648] EEA (2022 Unpublished) Progress in the management of contaminated sites.

55% of a sample of CSs investigated were illegal.[649] The problem is addressed to some degree in national strategies and regulations, however, there is high variance in the level of commitment and legislation to remediate across Member States.

The objectives to restore all soils to good health, and more specifically to remediate contaminated sites are both captured in this building block. Indeed, remediation of contaminated sites is considered in this context as a form of soil restoration. That said, where these objectives apply, the subsequent impacts, costs and benefits, and links with broader policy are somewhat distinct between the two. Hence, in the remainder of this section, for the baseline and assessment of options, the analysis is presented separately for: options to restore soils to good health and options to specifically target remediation of contaminated sites. However, these options still combine under the overall building block, and hence the analysis is brought back together to present a combined assessment in 'How do the options compare?'.

Baseline – restoration of unhealthy soils

The following table offers an overview of current strategies, regulations, and policies that may impact on soil health restoration. This is to act as a baseline to demonstrate what soil restoration activities may be taking place currently, and where the gaps are that the Soil Health Law can aim to resolve.

Table 6-1: Relevant policies to baseline for REST

Policy	Relevant component	Relevance to Restoration/Remediation Measures
Common Agricultural Policy (CAP)	Conditionality of direct payments (CAP 23-27)	Recipients of direct payments under the CAP will have to follow more stringent conditionality than previously, including crop rotation, and ensuring non-productive areas on arabla land.
	Eco-schemes (CAP 23-27)	As part of Eco-schemes, managing authorities must establish a 'list of agricultural practices beneficial for the climate change and the environment' based on the needs and priorities they have identified at national and/or regional level, which may include measures for the restoration of degraded soils.
	Good Agricultural and Environmental Conditions (GAECs) under the conditionality	The GAECs ensure certain management practices are put into practice and therefore have a restorative effect on soils, however there is no direct guidance or obligation given in the GAECs on measures to restore degraded soil to a healthy condition.
	Rural development programs (RDPs)	A key focus of RDPs may be on restoring, preserving and enhancing ecosystems related to agriculture and forestry depending on each Member State.
Land Use, Land Use Change and Forestry (LULUCF) Regulation	N/A	Revised methodologies could encourage land-owners to increase carbon sequestration in their soils through LUC, thereby contributing to restoring degraded soils.
Industrial Emissions Directive (IED)	N/A	Includes guidance on monitoring, and protecting soil from contamination with pollutants from industrial sources.
Nitrates Directive	Annex II: Code(s) of good agricultural practice; and, Annex III: Measures to be included in action programmes as referred to in Article 5(4)(a)	The Nitrates Directive doesn't include any measures specific to restoration of soil health, however this may be an indirect effect, as inadequate nutrient management can deteriorate soil health, while improved nutrient management can restore soil's natural, healthy chemical profile. Advice on managing stocking rates may contribute to restoring eroded/compacted soils.
Floods Directive	Article 7 – Flood Risk Management Plans	Indirect effect through tackling drivers of flooding: soil erosion, compaction, and soil sealing. Addressing eroded and compacted soils will improve soil physical conditions, structure, water retention, drainage, porosity, and thus contributes to restoring degraded soils to a healthy condition
National Emissions	Annex III: Content of national air	Particularly relevant to soil contamination, since some of the measures

[649] JRC (2018) Status of local soil contamination in Europe p. 45.

Policy	Relevant component	Relevance to Restoration/Remediation Measures
Reduction Commitment Directive (NECD)	pollution control programmes referred to in articles 6 and 10; and. Annex V: Optional indicators for monitoring air pollution impacts referred to in Article 9	relate to controlling ammonia emissions and aim at promoting the replacement of inorganic fertilisers by organic ones or spreading manures and slurries in line with the foreseeable nutrient requirement of the receiving crop or grassland with respect to nitrogen and phosphorous. Other measures relate to controlling emissions of fine particulate matter and black carbon and aim to improve soil structure through incorporating harvest residue or improve the nutrient status and soil structure through the incorporation of manure.
EU Soil Strategy	N/A	Aims to improve overall soil health so that by 2050, all EU soil ecosystems are in healthy condition and are thus more resilient, which will require very decisive changes in this decade. By 2050, protection, sustainable use and restoration of soil has become the norm. The Soil Strategy propose actions to achieve this, and contains a specific section on restoration.
Environmental Liability Directive (ELD)	Annex II: Remediation of land damage	The directive directly addresses contamination of soils, to ensure that relevant contaminants are removed, controlled, contained, or diminished, where levels reach a certain threshold so that there is no longer a risk to human health. Soil health can be indirectly improved by the aim of the ELD to restore natural habitats and water damage.
Biodiversity Strategy to 2030 and the proposal for a Nature Restoration Regulation	N/A	The core of this initiative are the legally binding EU nature restoration targets to restore degraded ecosystems (i.e. with high importance for biodiversity), and especially those with the most potential to remove and store carbon and to prevent and reduce the impact of natural disasters, to be established under the Nature Restoration Regulation.
Habitats Directive	Article 3	This directive legislates the conservation of natural habitats through protecting and where appropriate developing natural landscape features. Development of natural landscape features may also be a soil restoration strategy, and therefore there will be indirect benefits to soil restoration.
Land Degradation Neutrality (UN)	SDG 15	Under the SDG Agenda, the EU committed to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world by 2030.

The principles of restoring soil health and preventing further degradation are implied in some of the Directives and policies outlined above in the table. However, a specific obligation or deadline to restore unhealthy soils to a healthy condition, and guidance on what measures may achieve this are lacking. Therefore, it is likely that continuing with these baseline activities will not be adequate to achieve comprehensive restoration of soils.

As underlined in the proposed Nature Restoration Law, existing protection of natural resources like soil is not enough and dedicated restoration practices are required. Soil forms the base of many ecosystems that will be targeted by the Nature Restoration Law (i.e. forest, urban, agricultural ecosystems). Therefore, it is likely that these measures and targets may contribute to restoration of soil health. However, these may not be targeted directly to restoring soil health, and will cover many other areas including pollinating insects and river connectivity. A more targeted approach to restoring degraded soils is necessary to ensure comprehensive soil recovery. The preservation of natural resources, including soil, was mentioned as a potential impact in the initial impact assessment of the proposed Sustainable food system framework initiative.[650] This initiative is likely to contribute indirectly to improved soil health, however, like many of the other instruments discussed here the restoration of soil health will not be a key target and may be overlooked.

Some action is already being undertaken at Member State level, but again there are risks comprehensive restoration will not be achieved. For example, while the German Federal Soil Protection Act is an ambitious instrument with relevant objectives to restore soil functions, the focus is largely on preventing and rehabilitating contamination of soils, and waters contaminated by such

[650] Document Ares(2021)5902055

sites. This could mean that restorative practices for other soil degradation practices are largely overlooked. Similarly, the Agricultural Code of Wallonia directly mentions soil as a resource needing protection and management, but mainly focuses on agricultural soils, which may exclude other important soils from restoration.

The key gaps found across the current baseline are that where soil health is mentioned it is often as a beneficial side effect of the pursuit of other environmental objectives, rather than from a holistic policy approach with soil health at its core, meaning important sites and measures will be missed and comprehensive restoration will not be achieved.

6.1.2 REST - Option 2: Content of programme of measures defined by Member States

Description of option and requirements for implementation

This Option considers:

- EU to set a restoration obligation for all Member States, that all soil districts are healthy by 2050, and an obligation of restoration of unhealthy soils by 2050. The obligation of restoration applies to all unhealthy soils.

Option 2 contains the following specific element:

- There would be no requirement for programmes of measures included in the SHL, and it would therefore be left entirely up to Member States how to implement the restoration objective.

Mandating the achievement of healthy soils received strong support amongst stakeholders. In response to the OPC, 86% of respondents ‘totally agreed’ that the future EU Soil Health Law set obligations for Member States to achieve healthy soils by 2050. This was the most common response across all respondents (with the exception only of Business Associations, who were split fairly equally across all possible responses).

Assessment of impacts

The impacts of sustainable soil management and restoration may have significant overlap as these will both involve similar principles with the objective of improving soil health - for more detail on impacts see SSM Option 2. Because of this there will also be an overlap in measures that achieve both, and therefore the impacts of these measures. The extent of this overlap will depend on what measures are included under each building block and the intensity of these measures. The extent of the overlap is likely to be fairly large, but not a complete overlap as there are, however, key differences between the two building blocks:

1. The distinction between sustainable soil management and restoration is not always obvious. It depends on the status of the soil (healthy vs. unhealthy). Sustainable soil management is an act of good stewardship or a duty of care to prevent that a healthy soil degrades by maintaining or enhancing the provision of ecosystem services. Restoration is an intentional activity aimed at reversing or re-establishing soil from a degraded state to a healthy condition.

2. REST is considered as fixing a problem with a temporary implementation, whereas SSM involves ongoing measures. Once soil has been restored to a healthy level sustainable soil management can then take place with permanent implementation.
3. REST is to be implemented on soils deemed to be unhealthy as a result of the activities under SHSD/MON**. SSM practices would be applicable after REST practices have been implemented to continue maintaining soil health.**
4. REST measures implemented on unhealthy soils may need to be targeted to the specific soil health indicator(s) that a soil is unhealthy under. SSM on the other **hand** likely does not need to be as specific and the roll-out is more generalised**, depending on the selected options.**

The impacts of REST will depend on what is classified as an unhealthy soil and therefore needs to be restored, hence there is an intrinsic link with the SHSD building block and the thresholds and ranges defined for each descriptor. This will alter the area of soils requiring restoration and therefore the scale of economic and environmental impacts that will be felt – the area of soils potentially requiring restoration is explored in the following information box.

The impacts will also differ based on definitions of soils that are 'naturally unhealthy' and 'unhealthy but unrecoverable' and whether these are to be excluded from REST practices. This distinction will also impact the effectiveness of measures (irrespective of the area they are implemented on), and therefore alter the scale of impacts. The impacts of the REST building block will also depend on whether a land manager has to implement measures on any of their soil identified as being unhealthy, or will they have to implement measures that will restore a particular parameter to within a healthy range.

Information box – Analysis of areas of land not currently meeting proposed soil health descriptor thresholds

The impacts of the obligation to restore all soils to good health by 2050 will depend on a number of variables. One key variable are the ranges defined against each soil health descriptor – the choice of these ranges will define what is deemed as 'good health', and will hence have a direct impact on the area of land deemed 'unhealthy', and requiring restoration activities. The costs (and benefits) of restoration are likely to scale with the area of land to which they are applied. Hence there is a direct link between the choices made under the SHSD building block, and the costs of restoration measures required.

To explore this further, the EEA and JRC has undertaken analysis on the basis of the LUCAS 2018 survey to explore the areas of land which fall in different ranges relative to different soil health descriptors[651]. The results are presented in this information box. This information gives some indication of the potential magnitude of costs associated with the obligation, but does not tell the whole story – as noted the costs will depend on a range of variables, hence even if a large amount of land area is defined as 'unhealthy' against a given indicator, this does not necessarily imply high cost (for example if relatively low cost restoration activities are available to achieve good status against that indicator). Furthermore, this assesses all land against each descriptor individually and not in combination. Hence the areas of land assessed as 'unhealthy' against each indicator below are not directly additive to define a 'total land area that will be defined as unhealthy', as there could be some

[651] Trombetti et al. (2023). Report on soil quality mapping. European Topic Centre on Data Integration and Digitization. *Draft version v09, Dec. 2022; final version available by Q2 2023*

overlap (e.g. one parcel of land is deemed unhealthy against two or more indicators). Furthermore, data is not available to assess the areas of land deemed unhealthy against all indicators.

The first table below shows the agricultural land area across 25 Member States that falls outside different thresholds for ***phosphorous content***. As shown above, on the basis of the excess nutrient (phosphorous) descriptor (Member States to select maximum threshold between 30-50 mg/kg, see SHSD Option 3), around 48% of soils (or 86m ha) have a P content < 30 mg/kg, and 89% (or 161m ha) have a content < 50mg/kg across the 25 Member States. Hence, depending on the maximum threshold selected by Member States, anywhere between 11% to 52% of agricultural soils could be deemed unhealthy. The proportion of soils falling outside of this range varies widely across Member States: for example, with respect to the <30 mg/kg threshold, the proportion ranges from a minimum of 0% in Netherlands (meaning 100% would be deemed unhealthy) to 91% in Greece. Also demonstrated by the table is the sensitivity of the area of soils deemed unhealthy to the threshold selected – for example, reducing the bottom end of the threshold to 20mg/kg or even 10mg/kg would dramatically increase the area of land deemed unhealthy.

Table 6-2: Areas of agricultural soil (ha across 25 Member States) falling below thresholds for phosphorous content

	< 6 mg/kg (ha)	< 10 mg/kg (ha)	< 20 mg/kg (ha)	< 30 mg/kg (ha)	< 50 mg/kg (ha)	< 70 mg/kg (ha)
Total (25 Member States)	1,897,375	6,723,275	38,323,700	86,312,000	161,931,725	179,378,000
Total (25 Member States as % of total land area - % land healthy)	1%	4%	21%	48%	89%	99%

Source: EEA+JRC

Excess nitrogen in soil is also a proposed soil health descriptor, although no working threshold has been proposed (only monitoring). Only around 60% of the N applied to agricultural land in Europe is taken up by crops.[652] The surplus of N inputs on agricultural land in the EU-27, compared with the rate at which these are removed by crops, was estimated to total around 44.4 kilograms per hectare, in 2014.[653] Relatively high N surpluses are found in intensive livestock regions, including: north-western Germany, the Netherlands, Belgium, Luxembourg, Brittany in France and the Po Valley in Italy[654]. It is estimated that nitrogen use efficiency is at 61% and would need to increase to 72%-74% to offer a reasonable level of protection to water bodies.[655]

The table below shows the area of arable and permanent crops, and pastures and grassland across the 27 Member States that falls outside different thresholds for ***soil erosion***. Based on the soil erosion descriptor (see SHSD Option 3), around 55m ha currently experience a greater level of erosion than would be deemed 'healthy'. The areas at risk are higher for arable and permanent cropland, than pastures and grassland. These figures correlate to other studies which have sought to assess the problem of soil erosion – for example, a recent study[656] found that of the 110 million hectares of EU arable land, 43m ha are vulnerable to a single driver of erosion (the study investigated water, wind, tillage and harvesting), with 15.6m ha vulnerable to two drivers, and 0.81m ha to three or more

[652] https://www.sciencedirect.com/science/article/pii/S0269749111000625
[653] https://www.eea.europa.eu/publications/zero-pollution/cross-cutting-stories/nutrients
[654] https://www.sciencedirect.com/science/article/pii/S0048969721023548
[655] https://www.fertilizerseurope.com/wp-content/uploads/2020/03/Proc-842-de-Vries-short-abstract_-21-Feb.pdf
[656] https://www.nature.com/articles/s41893-022-00988-4

drivers. Likewise the EEA[657] estimate that ‘non-tolerable’ loss by water erosion for arable land, permanent crops and all agricultural land to be 20%, 56% and 23% respectively. The table also demonstrates that the area of land deemed unhealthy reduces significantly as the threshold for the maximum rate of erosion is increased, more than halving as the maximum is increased from 2 to 5 ton/ha/year, and again roughly halving between 5 and 11 ton/ha/yr.

Table 6-3: Land area (arable and permanent crops) falling outside thresholds for erosion (000 ha)

	arable+perm crops	pastures+grassland	arable+perm crops	pastures+grassland	arable+perm crops	pastures+grassland	Total	Total	Total
	>2 ton/ha y-1	>2 ton/ha y-1	>5 ton/ha y-1	>5 ton/ha y-1	>11 ton/ha y-1	>11 ton/ha y-1	**>2 ton/ha y-1**	**>5 ton/ha y-1**	**>11 ton/ha y-1**
Total (27 Member States)	41,952	12,873	18,464	6,219	11,947	1,898	**54,825**	**24,683**	**13,846**

Source: EEA+JRC

There are different approaches to define ***loss of carbon*** indicators, and based on the selection of the metric the results can vary. The table below shows the different areas of EU cropland and grassland that fall within different relative bounds against an ‘optimum’ SOC/clay ***thresholds*** (as defined by the JRC). Based on a maximum distance of 60% to the optimum, around 50% of land (or 57.4 million ha) would be deemed unhealthy (i.e. has a SOC/clay ratio of 60% or more relative to the optimum). Again the table shows the variance in the area of land as the threshold is flexed between different threshold levels. Likewise the underlying evidence suggests that these levels vary significantly by Member State: from some Member States with very low, if not zero, land areas with a SOC/clay ratio of 60% or more relative to the optimum (i.e. Estonia, Finland, Ireland and Lithuania, indicating substantial if not all soils as healthy against this descriptor), to Member States with very high proportions of land falling with a SOC/clay ratio of 60% or greater relative to the optimum (e.g. Spain, Greece and Bulgaria where more than 80% of land is measured to be above the 60% threshold relative to optimum, and hence unhealthy).

Table 6-4: Proportion of land area (cropland and grassland) disaggregated by distance to optimum SOC stock based on data collected through the LUCAS SURVEY

	>=45 (ha)	50 (ha)	55 (ha)	60 (ha)	65 (ha)	70 (ha)	75 (ha)	80 (ha)	85 (ha)	90 (ha)	95 (ha)	>=100 (ha)

[657] EEA_2022_extract soil health maps

Total (million ha)	72.8	68.0	62.8	**57.4**	51.8	46.3	40.8	35.5	30.5	25.8	21.5	17.6
Total %	63.9%	59.7%	55.1%	**50.4%**	45.5%	40.6%	35.9%	31.2%	26.8%	22.6%	18.8%	15.5%

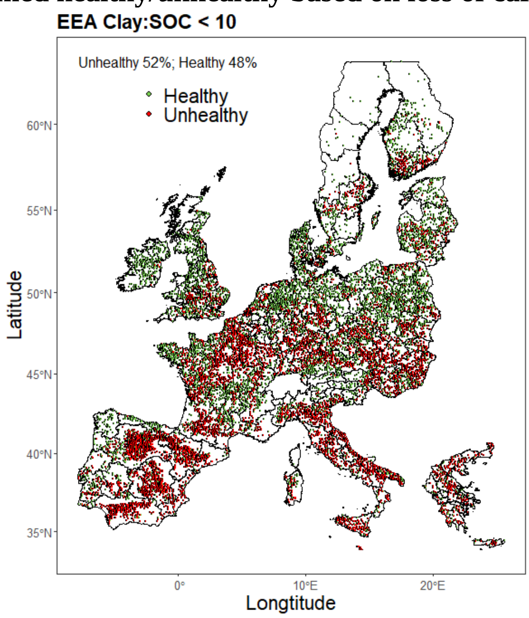
Source: EEA+JRC

The proposal for loss of carbon is (see SHSD – Option 3):

- For organic soils: respect EU targets set at national level under the NRL (wetlands);
- For managed mineral soils: SOC/Clay ratio > 1/13; MS can apply a corrective factor where specific climatic conditions would justify it, taking into account the actual SOC content in permanent grasslands.

Analysis has not been undertaken for the proposed threshold specifically, but the following figure shows the results applying a more stringent SOC/clay ratio of > 1/10. The application of the single threshold method (Clay:SOC > 10) returned shares between healthy and unhealthy soil classification of 48:52 for the Clay:SOC indicator. The majority of unhealthy classifications are observed in Member States characterised by a relatively warm climate such as the Mediterranean basin. This further supports the long standing rational that SOC content is mainly driven by geographical variation in temperature.

Figure 6-1: Proportion of soil deemed healthy/unhealthy based on loss of carbon (SOC/clay ratio > 1/10)

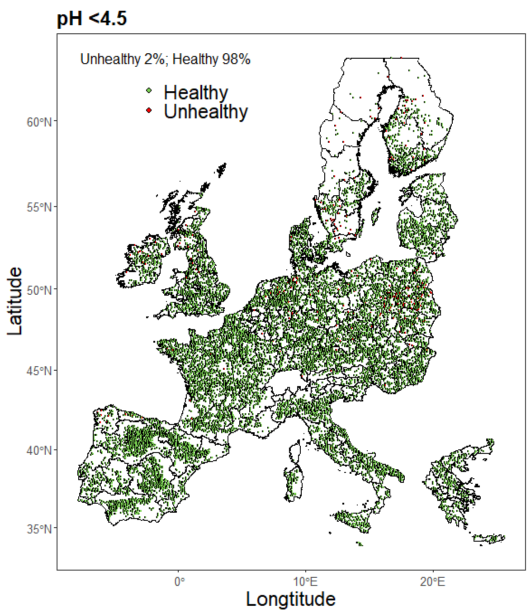


Source: EEA+JRC

Analysis has also been undertaken around ***acidification***, as presented in the following chart. No range has been defined for acidification, but as presented in the figure below, around 2% of soils could be deemed unhealthy should a threshold of pH 4.5 be defined EU-wide (but noting this could capture naturally acidic soils which would not be subject to restoration measures). By contrast, the

EEA[658] note that 6.9% and 2.4% of arable land and permanent crops respectively exceed 'critical pH levels' for crop production.

Figure 6-2: Map of acidification (pH levels)



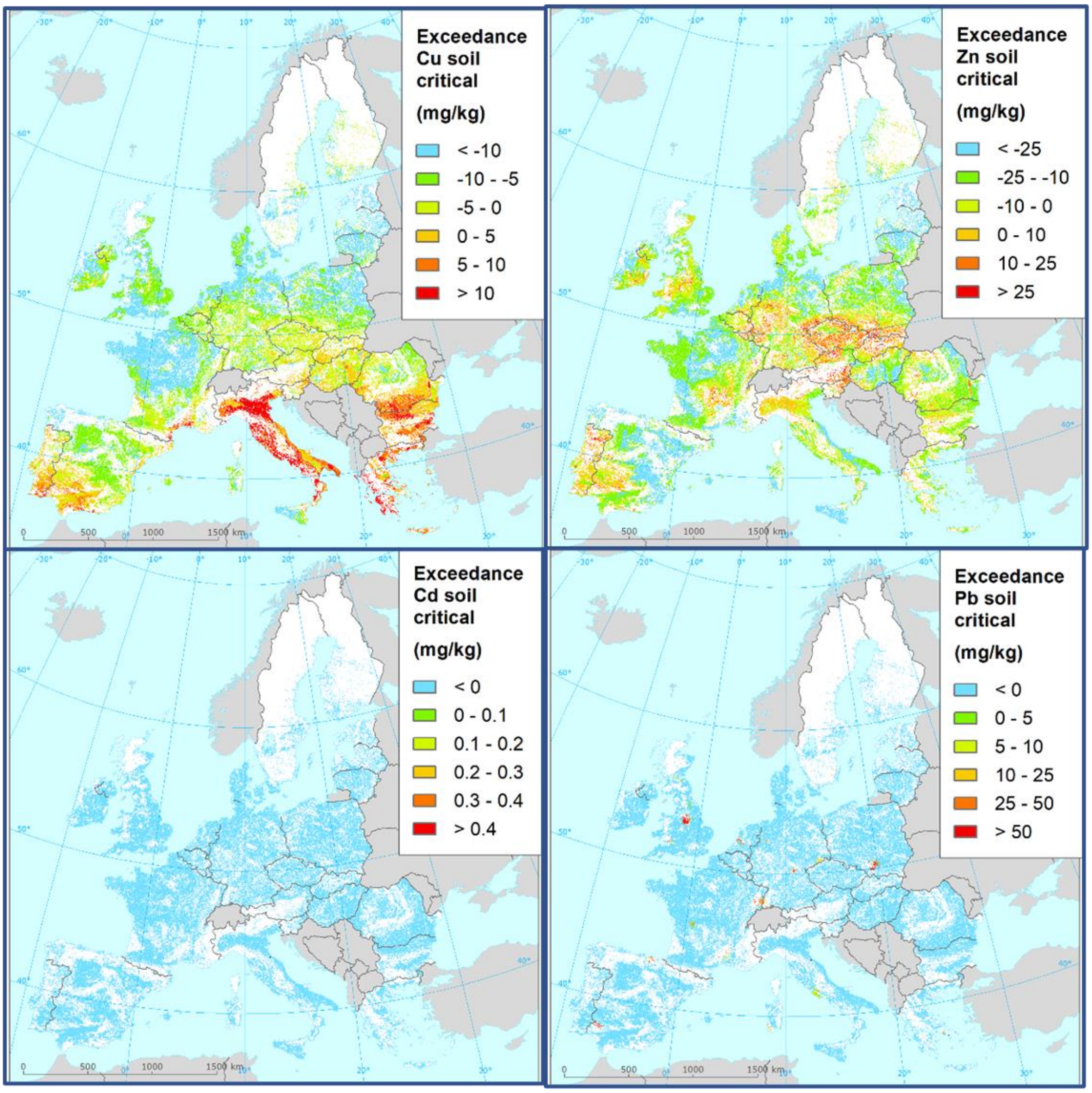
Source: EEA+JRC

Information on other indicators is available from other sources and previous analysis. For example, the EEA[659] have previously noted studies estimating that around 23% of total agricultural area of Europe has a critically high level of ***compaction***. This somewhat corroborates estimates by the EEA[660] regarding subsoil compaction, which notes that 58% and 69% of arable land and permanent cropland respectively would fall within a 'precaution value', whereas 9.2% and 9% of arable land and permanent crops respectively would fall within an 'action value' (although it is not possible to compare these directly to the threshold of: Sandy <1.8; Silty <1.65; Clayey <1.47, or Member States can replace this with equivalent parameter and range and either these values are achieved or Member States can demonstrate that actions were taken to: restore and compensate the loss of ecosystem services as much as possible and to avoid or reduce the pressures for subsoil compaction as much as possible).

[658] EEA_2022_extract soil health maps
[659] https://www.eea.europa.eu/publications/soil-monitoring-in-europe-indicators-and-thresholds/download
[660] EEA_2022_extract soil health maps

For ***soil contamination***, Member States must achieve reasonable assurance that no unacceptable risk for human health and the environment exist. The EEA estimates that 23% and 18% of arable land (including pasture) exceeds a threshold for copper (Cu) and zinc (Zn) respectively,[661] particularly in areas of intensive livestock,[662] whereas as the area of arable land exceeding critical thresholds for cadmium (Cd) and lead (Pb) are much smaller. The level and location of exceedance varies by metal, as shown in the maps below. For example, areas exceeding critical copper levels appear to be concentrated more in southern Europe, in particular, Italy and Greece. For zinc, greater exceedances of critical levels are found in eastern Europe, e.g. in Slovakia, Hungary, Chechia and Austria. Exceedances for lead are observed to be much more concentrated on fewer, more polluted sites. Data is more limited around the range and levels of pollution from organic pollutants.

Figure 6-3: Arable land (including pasture) exceeding critical levels for heavy metal exceedance



Source: De Vries et al. (2022)[663]

[661] EEA zero pollution monitoring assessment 2022 - https://www.eea.europa.eu/publications/zero-pollution/ecosystems/soil-pollution
[662] See footnote 615.
[663] https://eur03.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.eionet.europa.eu%2Fetcs%2Fetc-di%2Fproducts%2Fimpacts-of-nutrients-and-heavy-metals-in-european-agriculture-current-and-critical-inputs-in-relation-to-air-soil-and-water-quality%2F%40%40download%2Ffile%2FD22%25201821%2520M1%2520and%2520M2%2520Nutrients%2520and%2520heavy%2520metals%252

Data shows that despite reductions in the past decades, **land take** is still represents a substantial proportion of land in the EU. In 2018, artificial land covered 174,792 km^2 of soil in the EU 28, representing 4.2% of its total land surface.[664] Land take has essentially occurred at the expense of urban areas and of croplands, for surfaces of 8,678 km^2 and 6,680 km^2 respectively since 2000. When considering net land take (i.e. land take from which land return to non-artificial land categories is subtracted), it appears that this net land take remains strongly positive, as ten times more land has been taken (approximately 12,000 km^2 taken) than recultivated (1,200 km^2 recultivated) between 2000 and 2018.[665] Land take is particularly problematic when coinciding with soil sealing (which can be classified as the most intense form of land take). In the EU-27, the latest data (2015) indicates that over 77,000km^2 (1.77% of total terrestrial area) of land in the EU-28 is sealed.[666] Soil sealing has increased by 78% since the 1950s.[667] The average absolute EU-27 area of soil sealed between 2006-2015 was approximately 332km^2 per year, reaching a cumulative area of 2,989km^2. Nevertheless, the absolute total area of soil sealing between this time period has decreased in intensity.

The 2006 Impact Assessment around a proposed Soil Framework Directive noted that around 3.8m ha in Europe are affected by ***salinisation***[668], with the most affected regions being: Campania in Italy, the Ebro Valley in Spain, and the Great Alföld in Hungary, but also areas in Greece, Portugal, France, Slovakia and Austria.

The following table presents analysis by the JRC at Member State level assessing the proportion of agricultural land in each Member State that would be defined as degraded against different descriptors based on exceedance of critical thresholds.

0in%2520soils%252001032022%2520ETC-DI_30March.pdf&data=05%7C01%7CDavid.Birchby%40ricardo.com%7Cd37b2ac600cb4088c2da08daef4076ed%7C0b6675bca0cc4acf954f092a57ea13ea%7C0%7C0%7C638085357567798964%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000%7C%7C%7C&sdata=koV8q0fZpAtIq7T0OrCyuT3Lj9xpD32A606Sj4xKWds%3D&reserved=0

664 EUROSTAT (2021) Land covered by artificial surfaces by NUTS 2 regions. Available at: https://ec.europa.eu/eurostat/databrowser/view/lan_lcv_art/default/table?lang=en

665 EEA (2022) Land take and net land take, Land take statistics by country. Available at: https://www.eea.europa.eu/data-and-maps/dashboards/land-take-statistics#tab-based-on-data.

666 EEA (2019) Imperviousness in Europe. Available at: https://www.eea.europa.eu/data-and-maps/dashboards/imperviousness-in-europe

667 EEA (2022) What is soil sealing and why is it important to monitor it? Available at: https://www.eea.europa.eu/help/faq/what-is-soil-sealing-and

668 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52006SC0620&from=EN

Table 6-5: Proportion of agricultural land defined as degraded in different Member States based on exceedance of critical threshold for different soil health descriptors

NUTS_ID	EROSION	ACIDIFICATION	SOC DEFICIENCY	SUB-SOIL COMPACTION	Cd in view of Food safety	Cu in view of biodiversity	Zn in view of biodiversity	P based on crop yield	N input in view of NH3 emission
AT	33.7%	5.5%	48.2%	2.0%	0.0%	33.3%	57.2%	20.7%	21.7%
BE	10.0%	1.9%	7.6%	7.6%	0.0%	0.1%	16.3%	98.5%	87.9%
BG	22.0%	0.1%	NA	21.8%	0.0%	96.9%	12.5%	1.4%	69.9%
CY	NA	NA	90.0%	33.8%	NA	NA	NA	NA	NA
CZ	31.5%	5.5%	40.9%	5.1%	0.0%	11.7%	72.0%	0.9%	93.0%
DE	14.0%	9.9%	12.1%	2.3%	0.0%	1.8%	27.3%	15.6%	91.6%
DK	0.2%	16.4%	0.0%	0.4%	0.0%	0.0%	0.8%	2.0%	98.2%
EE	0.8%	3.4%	0.0%	46.0%	0.0%	0.0%	0.0%	0.1%	29.1%
EL	38.9%	0.0%	83.1%	10.1%	0.0%	95.4%	8.7%	69.4%	96.8%
ES	43.0%	0.6%	80.4%	11.7%	0.0%	23.2%	5.2%	70.1%	90.6%
FI	0.6%	65.0%	0.4%	54.8%	0.0%	1.0%	6.0%	1.1%	33.9%
FR	20.1%	0.7%	45.8%	2.0%	0.0%	4.8%	1.1%	13.4%	72.6%
HR	11.7%	NA	NA	3.0%	NA	NA	NA	NA	NA
HU	13.0%	0.1%	71.3%	2.3%	0.0%	40.7%	10.6%	4.2%	83.3%
IE	8.2%	1.5%	0.0%	13.6%	0.0%	1.7%	12.1%	19.0%	99.9%
IT	56.7%	0.1%	72.9%	16.7%	0.0%	79.3%	19.6%	80.0%	94.0%
LT	1.3%	1.8%	0.0%	28.3%	0.0%	0.0%	0.0%	1.1%	96.5%
LU	50.8%	12.6%	28.1%	0.9%	0.0%	0.0%	65.7%	15.5%	68.8%
LV	0.9%	2.2%	0.0%	33.5%	0.0%	0.0%	0.0%	0.0%	13.7%
MT	NA	NA	11.1%	18.4%	NA	NA	NA	NA	NA
NL	0.2%	9.9%	10.0%	6.6%	0.0%	0.0%	3.7%	96.7%	98.1%
PL	8.4%	16.4%	2.2%	1.5%	0.2%	0.2%	15.1%	65.8%	92.6%
PT	35.7%	14.5%	36.6%	5.6%	0.0%	75.6%	63.9%	36.2%	81.1%
RO	25.4%	0.7%	NA	3.9%	0.0%	57.8%	6.8%	3.4%	69.1%
SE	8.5%	47.8%	0.3%	11.0%	0.0%	0.0%	10.6%	5.8%	40.1%
SI	44.0%	9.4%	40.3%	2.5%	0.0%	93.4%	93.6%	6.9%	73.2%
SK	29.0%	2.4%	78.2%	0.9%	0.0%	69.1%	64.9%	1.3%	92.9%

Source: EEA+JRC

Economic

Measures taken to restore soil health would carry a cost, potentially both an upfront investment cost and ongoing operating cost. Again, it is uncertain where these costs will fall as it will depend on the means of implementation chosen by each Member State – but in the first instance these costs are allocated to the Member State given this is where the obligation is placed. The Soil Health and Food Mission Board, and the European Commission's JRC reviewed current evidence on the state of EU soils and estimated that current management practices result in 60-70% of EU soils being unhealthy,[669] however this value may alter depending on the future actions under SHSD. It indicates the scale of land that is currently not providing any services, or underproviding, because it is not in healthy condition.

The State of Finance for Nature report[670] by the UNEP explores the annual investment in nature-based solutions required to limit climate change to below 1.5°C, halt biodiversity loss and achieve land degradation neutrality. The analysis captures the costs associated with deployment globally of a range of soil restoration (reforestation, restoration of peatlands, avoided deforestation, peatland and grassland protection, and protection of protected areas) and sustainable land management practices (agroforestry silvopasture, agroforestry silvoarable, cover crops, grazing-optimal intensity). This is in addition to several non-terrestrial restoration and protection measures. The report estimates that globally an additional USD 330bn is required annually by 2030, rising to USD 520bn annually at a global level to implement restoration, sustainable land management and protection measures to limit climate change to below 1.5°C. In the EU, the annual finance gap to increase protected areas to 30% by 2030 (as defined in the 30x30 target proposed in the Post2020 Global Biodiversity Framework) is estimated to be an additional USD 2.7bn pa to achieve 30x30, with only USD 0.6bn pa required to meet minimum budget for current TPAs (both figures are additional to current spending on Terrestrial Protected Areas – or TPAs - of USD 9.3bn pa).

Many restoration measures could deliver a positive economic benefit where applied optimally. Restoring this 60-70% of unhealthy lands to a healthy condition should increase the ecosystem services provided by soil and the economic, environmental, and social impacts by a similar scale. It has been estimated that halting and reversing current trends in soil deterioration has the potential to create 1.2 trillion euro per year in economic benefits[671]. Further to this, every €1 investment in land restoration brings an economic return of €8 to €38.[672] The potential for economic returns, and their significance, will vary depending on the measure type, location and extent to which is it implemented, which will in turn determine the potential to increase the value of the land and therefore the value of the services the soil provides.

Soil restoration measures can improve fertility and yield. Severely eroded croplands are estimated to contribute to a loss in agricultural productivity of €1.25 billion per year in

[669] EC (2020), Caring for soil is caring for life
[670] https://wedocs.unep.org/bitstream/handle/20.500.11822/41333/state_finance_nature.pdf?sequence=3
[671] EC (2021), EU Soil Strategy for 2030
[672] EC (2022), Nature Restoration Law Assessment sheet

the EU.[673] The impacts of soil restoration on the conduct of a business will be more substantial and noticeable in the long-term compared to the short-term as the differences in yield from one year to another may be less than the variation caused by changes in weather.[674] REST measures can also often require lower labour inputs than conventional management practices that may currently be in place on farms, which could lead to financial saving for farms with employed workforces.

As stated previously, the economic impacts of REST are similar in nature to those of SSM, as both building blocks will result in improvement to the health, and therefore, the economic (and ecosystem services) benefits provided by soil. However, there will be differences drawn based on the type of land and the degree of degradation, and therefore the measures implemented. For example, a key restoration method may involve ensuring the land is under an appropriate management system or use for ensuring a healthy condition and natural function of the soil. Soil under intensive arable management that is found to be unhealthy may be restored through incorporating set-aside and natural vegetation into the land management system. This may potentially remove land from food production, reducing overall yields and income for farmers, however this is likely in the short term as soils become healthier and return to food production. Unhealthy soils in an abandoned industrial area can also be restored through appropriate land management systems. These new systems can open up new economic streams in the area from provision of food or raw materials, and tourism. The restoration project in the Emscher Industrial Park in Germany, can be seen as an example of restoration of soils in an urban area through introducing new land management measures. This resulted in newly restored natural habitats, regenerated brownfield sites and recreational areas that boosted the economy in the surrounding area.[675,676]

Restoration of soils in urban areas can be expensive to implement, with the key benefits being focused on the environmental and social impacts of the projects. The ongoing LIFE LUNGS project in Lisbon, Portugal is evidence of this where an EU contribution of over 1.5 million EUR (total budget of 2.74 million EUR) is being used to improve the green infrastructure of the urban areas. This money may only have indirect positive economic impacts through, for instance, a more resilient food supply and climate adapted urban farming, however the environmental impacts are expected to be great (see below for further details). Furthermore, the example of the Emscher Industrial Park, discussed above, shows that restoration in urban areas can attract both residents and tourists that will boost the local economy.

Peatland restoration has similar impacts in that the environmental benefits are the main driver, while they can be costly form an economic perspective. The EU LIFE funded Living Bog Project in Ireland which aimed to re-create 750 hectares of active raised bog, and improve 2,649 hectares of bog habitat. This type of activity will have significant environmental benefits that are discussed in greater detail below (See Environmental section below). The 5 year long project received over EUR 4 million in funding from the EU.

[673] EC (2022), Nature Restoration Law Assessment sheet
[674] Brady, M.V. et al., (2019), Roadmap for Valuing Soil Ecosystem Services to Inform Multi-Level Decision-Making in Agriculture
[675] https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law/success-stories_en
[676] https://climate-adapt.eea.europa.eu/en/metadata/case-studies/a-flood-and-heat-proof-green-emscher-valley-germany/11305605.pdf

The economic impact of REST will depend on how unhealthy the soil is initially and by what indicators is found to be unhealthy, which will then determine what restoration measures are required. The economic impacts of restoration measures will hence critically vary depending on the thresholds selected for each descriptor under SHSD. This variance is illustrated somewhat by the quantitative data presented in the Information Box above. For example:

- The proposed healthy range for maximum phosphorous content is 30-50 mg/kg, leaving 58% of EU agricultural soil currently unhealthy. If the range was widened to say 20-70 mg/kg, the area of land defined as unhealthy would reduce to 22%.
- The proposed unhealthy threshold range for erosion is >2 tonnes/ha/yr, leaving 55m ha of EU-land as unhealthy. If the threshold was increased to 5 tonnes/ha/yr, the area of land deemed unhealthy would halve.
- The baseline reference threshold for SOC relative to the optimum SOC is defined as a difference of 60%, leaving around 50% of EU cropland and grassland defined as unhealthy. If this difference threshold was reduced to say 75%, 36% of cropland and grassland would be defined as unhealthy.

The area of land that is deemed unhealthy will directly drive the costs (and size of costs) associated with the restoration obligation, as this is directly the area of land that will require restoration activity to take place (that said it will also directly drive the size of the benefits). However, it is not the only variable that will determine the costs. Furthermore, although it is likely that costs will scale with the land area defined as unhealthy, it is challenging to robustly conclude how costs will scale as this it is conceivable that costs would not always scale linearly and there would be some non-linear effects: for example, where a restoration activity improves soils across multiple districts, but would be required under different threshold scenarios (say where one district is further outside a given threshold), and/or where the effects of restoration activities available are more step-wise in fashion (say where a given restoration action would deliver significant improvement, but cannot offer more granular, scaled down improvements).

Stakeholders have suggested that costs of restoration could be offset by economic instruments and positive incentives such as quality benchmarks, true pricing, and locally produced products.[677] This can help create a level playing field, which could encourage soil restoration activities. It has also been suggested that financing for businesses should cover research and innovation to develop new restoration technologies or methods, which can then both the management and restoration of soils, and boost the economy.[678] An example of this can be seen in soil restoration project in the municipality of Piacenza, Italy.[679] The cost for 10 ha and 150,000 m^3 of reconstituted soil amounts to 147,500 € with project's technology (vs 2,100,000€ with conventional methods). Such a low cost is obtained thanks to the use of green waste matrices which represent not a cost, but an income (as the companies producing them have to pay for their disposal). According to Land Capability Classification LCC , the area where the project applied its technology has been improved from category V/VI (severe limitations, unsuited for cultivation) to category II (moderate limitations in the choice of plants). This corresponds to an increase of value from 6,500/12,000€/ha, to some 50,000/70,000€/ha (prices relevant for the

677 OPC Stakeholder Feedback, Dutch Response by Email
678 Ibid.
679 https://www.bpi.gr/files/SOIL/soil%20PRESENTATIONS-site/LIFE10%20ENV%20IT%20000400%20NEW%20LIFE.pdf

Piacenza area), with a cost per ha of about 14,750 €.[680] This project allowed for further development of new technologies for soil restoration, and while the applicability of this specific technique is not very wide (due to the patent involved and regulations surrounding reuse of waste materials), it is evidence of the economic return and developments in technology that can come from investment in soil restoration.

Economic – Option 2

Option 2 will leave restoration activities up to Member States, which means there could be significant variation in what is implemented, compared to Options 3 and 4, where there is increasing guidance coming from the EU. This may cause lower environmental ambition in the activities and projects undertaken within each Member State, as this may conserve costs. This may allow for more effective cost delegation where Member States can have a keener understanding of the needs of the regions and therefore target these particular issues in their restoration strategies. This may allow for a more economically streamlined approach, but the lack of clarity as to what activities constitute restoration and the variability amongst Member States could also hamper this.

A key difference between the options is with respect to ***administrative burdens.*** The most significant additional administrative burden is likely to be for Member States to adopt national measures (total upfront in the region of EUR 6.75 m, and ongoing annual cost of EUR 1.35 m). There may be a small additional cost to the EC to monitor these measures, both upfront and ongoing costs of less than EUR 100,000 each. **Error! Reference source not found.**below provides a comparison of administrative burden across the options.

Table 6-6: Total administrative burden across REST options

Option number	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-off costs	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 2	4,100	74,000	450,000	1,400,000	-	-	460,000	1,400,000

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

Environmental

The principle of REST (and a key benefit) is the restoration of the health of the soil (***Quality of natural resources (water, soil, air etc.)***). For example:

- Application of organic amendments, such as farmyard manures, may be beneficial for restoring soils depleted in organic matter or organic carbon (however this can also increase the bulk density and reduce the porosity of soils, compounding structural damage to soils, and thus may not be a feasible option for restoring structurally degraded soils).[681]

[680] Life programme excel
[681] Alaoui, A. and Schwilch, G. (2019), Database of currently applied and promising agricultural management practices

- Subsoiling/deep-tillage/inversion tillage is a practice that has the potential to restore soils with unhealthy structure/compaction by aerating it, increasing drainage, and breaking up soil aggregates (however the principle of it is contrary to conservative agriculture and sustainable soil management, and thus may have some temporary negative impacts such as releasing carbon from soils).

Improving soil health will have knock on effects on the ***quality of both water and air***. Restoration of the structure and porosity of soils will aid in the storage and infiltration of water, reducing standing surface water and therefore the risks of flooding, drought, and soil erosion.[682,683] Healthy soils can also improve cycling of nutrients, through improved filtration of water and reduced leaching, improving the quality of drinking water.[684,685]

REST has the potential to have significant ***climate*** change benefits as achieving net-zero greenhouse gas emissions by 2050 relies on carbon removals through the restoration and better management of soils.[686] The ongoing LIFE LUNGS project in Lisbon, Portugal is a contemporary example of benefits to soil health that nature restoration. It will directly target soil health through increasing resilience to soil erosion of around 115 ha of land, and increasing carbon levels of soil (approx. 740 tons of CO_2 to be sequestered).

Restoration of drained peatland soils specifically has significant potential for sequestering carbon. Globally, about 15% of peatlands have been degraded through draining for agriculture, extracted for horticulture, or burned and mined for fuel.[687] Europe has experienced large peatland losses with over 50% of former peatlands no longer accumulating peat, with 46.4% of the total 58.8 million hectares of peatlands in Europe, currently considered as degraded.[688] In the EU, more than 5% of all GHG emissions come from degraded peatlands.[689] In some European countries (including the UK), drained peatlands contribute to more than 25% of total emissions from agriculture and agricultural land use, thus highlighting the significant potential for accumulating carbon in soil in carrying out restoration of peatland soils.[690] Restoration of drained peatlands could save up to 25% of Europe's land-based greenhouse-gas emissions.[691] Feedback from Member States has indicated that there is growing interest in rewetting of drained peatlands as a form of soil restoration.[692]

The climate benefits offered by restoration practices are re-iterated by the State of Finance for Nature report[693] by the UNEP, which explores annual investment in Nature-based solutions required to limit climate change to below 1.5°C, halt biodiversity loss and achieve land degradation neutrality. It estimates the potential for GHG removals by nature-based solutions globally over the period to 2050. Several soil restoration measures show significant potential for GHG removals, in particular: reforestation (around $5GtCO_2eq$ pa by 2050), agroforestry (around $2GtCO_2eq$ pa by 2050), restoration of

682 EC (2020), Caring for soil is caring for life
683 The Business Case for Investing in Soil Health
684 EC (2020), Caring for soil is caring for life
685 The Business Case for Investing in Soil Health
686 EC (2021), EU Soil Strategy for 2030
687 EC (2020), Caring for soils is caring for life
688 UNEP, State of the World's Peatlands: Evidence for action toward the conservation, restoration, and sustainable management of peatlands (2022)
689 Ibid.
690 ibid.
691 EC (2022), Nature Restoration Law Assessment sheet
692 Stakeholder Interviews, Germany, 2022
693 https://wedocs.unep.org/bitstream/handle/20.500.11822/41333/state_finance_nature.pdf?sequence=3

peatlands (around 2GtCO_2eq pa by 2050), avoided deforestation (around 4GtCO_2eq pa by 2050), grassland protection (around 0.5GtCO_2eq pa by 2050) and peatland protection (around 3GtCO_2eq pa by 2050).

Soil ***biodiversity*** is often depleted in soils with consistent, intense soil disturbance i.e. tillage, and therefore reducing these tillage practices can help restore soil microbial biomass in unhealthy soils[694] [695]. Practices involving the principle of natural regeneration to achieve restoration of soils (e.g. set-aside) may confer further benefits for biodiversity by providing food sources and habitats for a variety of animal species.[696] Increasing soil biodiversity has also been linked to furthering some of the benefits outlined above including control of greenhouse gases, retention of nutrients and biotic resistance to pests.[697] Restoration measures can also increase pollinator population, which then has a knock-on impact to increase crop pollination and yields. Increasing the area covered by natural vegetation will increase the diversity and richness of pollinating species in the surrounding area through providing habitats and food sources.[698]

The main focuses of urban soil health is on appropriate planning in urban areas to reduce soil sealing and contamination from urban activities, and where necessary and possible, to reverse what has already taken place. These actions aim to restore soil to a healthy state where it will be able to provide ecosystem services many of which are outlines above including storage and filtration of water, biodiversity, and carbon sequestration (For more information on reducing land take see LATA Assessment, and for soil contamination see DEF and REST Assessment).

Soil restoration in urban areas can provide greater green areas, biodiversity and aesthetic values of the urban landscape which can improve the quality of life for residents, as well as boosting tourism. For example, a LIFE-funded project focused on the rehabilitation of the urban environment in Aranjuez, which had objectives of diversifying growth of market gardens and recovery of organic urban waste to form composts that could be returned to the urban soils improving their health.[699] LIFE has also funded a project focused on land acquisition in the Donana district, Spain, for the consolidation of nature conservation efforts in the area: This allowed for the acquirement of unhealthy, conflicted and, which could then undergo rehabilitation to its natural state.[700] These projects are examples of the environmental benefits that can come from improving the health of soils, as part of nature rehabilitation in urban areas. Restoration of some urban soils may require intense action, greater than that of SSM, depending on the threat and how unhealthy the soil is. Once restored however, ongoing SSM should be continued to ensure the healthy condition is maintained.

This example of restoration in urban environments also evidences how soil restoration can allow for adaption to the pressures of climate change, as well as offering mitigation opportunities. While soils offer an important solution to many issues and drivers of climate change, there may also need to be adaption so they can still provide ecosystem

[694] Soil biodiversity and intensive agriculture, Policy Brief from SoilService Project
[695] de Vries, Franciska et al. (2013), Soil food web properties explain ecosystem services across European land use systems
[696] Gómez, J.A. et al. (2021), Best Management Practices for optimized use of soil and water in agriculture.
[697] Soil as natural capital: Agricultural production, soil fertility and farmers economy, Policy Brief from SoilService Project
[698] Liquete, C. et al. (2022), Scientific evidence showing the impacts of nature restoration actions on food productivity
[699] https://webgate.ec.europa.eu/life/publicWebsite/project/details/679
[700] https://webgate.ec.europa.eu/life/publicWebsite/project/details/913

services under different climatic conditions, such as diversifying plants/crops grown and/or opting for plants capable of growing under these changing conditions.

Environmental – Option 2

Similar to the economic impacts, the environmental impacts specific to Option 2 will be related to the ambition of activities opted for by Member States. While control being in Member States over the restoration project may allow for a more targeted approach to the soil and environmental needs or threats locally and with this improve the environmental benefits, it is also expected that it could result in lower ambition, and therefore possibly reduce the benefits. This is difficult to assess without knowing for definite how the Member States may approach this.

Social

Public attitudes moving towards climate and sustainability awareness and conscientiousness means that improving soil health, and ecosystems services as a result, will likely ***improve social perception of farming.***[701]

There is an argument that some REST practices are less labour intensive, which may improve farmers' well-being/work-life balance (particularly on small farms). However, on larger farms with employed work forces this reduced labour input may result in loss of ***employment***. Contrary to this however, some practices can increase labour inputs such as needing manual weeding to replace/limit the use of pesticides[702]. The impact of REST on labour needs will therefore be dependent on how unhealthy the soil is initially, the size of the farm, and the intensity of the measures in the programmes of measures.

Floodplains and wetlands absorb floodwaters more effectively and at lower cost than any man made structure.[703] Restoration of these lands will offer an important service to the ***safety*** and infrastructure of societies living in these areas.

The contribution to ***Sustainable Development*** cross cuts the three broad areas discussed above. While their main function may be to restore unhealthy soils, practices such as cover crops, hedgerows, and set-asides can also aid in reducing wind and water erosion, reducing flood risk, providing habitats for animal species, and improving the aesthetic value of the land.[704] This additional functionality may help growth of business and livelihoods in the surrounding areas beyond simply agriculture e.g. tourism, markets, infrastructure.[705] It has been reported in some Member States, that soils contribute to the constitution of the common heritage of a nation. Therefore, the restoration of soils is important to protect this heritage and the ecosystem services and use values produced by it.[706]

Social – Option 2

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[701] The Business Case for Investing in Soil Health
[702] Alaoui, A. and Schwilch, G. (2019), Database of currently applied and promising agricultural management practices
[703] EC (2022), Nature Restoration Law Assessment sheet
[704] Buckwell, A., Nadeu, E., Williams, A. 2022. Sustainable Agricultural Soil Management: What's stopping it? How can it be enabled? RISE Foundation, Brussels.
[705] Gómez, J.A. et al. (2021), Best Management Practices for optimized use of soil and water in agriculture
[706] Expert Stakeholders (FR response to Sustainable Use)

Social impacts specific to Option 2 will depend on what specific actions are implemented within each Member State. It is expected that under this option these impacts will be less than under options 3 and 4, where more ambitious projects can be expected. This means the scale of the impacts will be lower under this option but what these impacts are likely to be those discussed under the common option above.

Distribution of effects

All options under this building block place the obligation of restoring soils to good health with the Member States. Member State Competent Authorities will be responsible for ensuring both that restoration measures and programmes are enacted on unhealthy soils and that unhealthy soils are restored to a healthy condition. Hence, most adjustment costs and administrative burdens will fall to Member States in the first instance. It is uncertain where these costs will fall as this will depend on the method of implementation in each Member State. Landowners/managers with unhealthy soil will have a role to play in putting the REST measures into practice on their land.

Landowners/managers will also be the key beneficiaries of soil restoration. Soil is their key asset and increasing the value of the soil will increase the value of outputs of their system. However, this may differ where land is leased/rented out (managed by someone who does not own the land), and the costs and benefits may be felt by different parties.

The individual communities/societies living in the locality of these degraded soils will also be effected by the impacts discussed above. They may feel benefits from improved water drainage and flood protection, a more secure food and water supply. These benefits are also likely to benefit future generations. The implementation of this building block allows contemporary generations to fix current problems and not pass these on.

Restoration measures are likely to predominantly impact rural areas. Some measures will be delivered in urban areas: The restoration of soils in urban areas may impact on development projects in urban areas (e.g. construction) through introduction of new land use planning, or reversal of previous inappropriate or defunct soil sealing. Ensuring urban soils are restored to a healthy condition by 2050 may involve preventing of actions that inhibit soil restoration cause further deterioration. This will also encourage more sustainable development of industry, residence, and tourism in urban areas[707,708] (See LATA Assessment for more information). That said, the impacts in rural areas are anticipated to the larger given: agricultural and forestry land represents a greater land area (around 80% of the EU's land area), soils are more actively managed, nutrients are applied in greater amounts and a lower proportion of rural land is inaccessible. As a consequence, the costs of implementing these measures will also fall more on rural areas, but also the majority of the benefits of implementing these measures would also fall to rural areas (e.g. productivity improvements through increase in yield or input cost savings).

Risks for implementation

[707] https://sustainablesoils.org/images/pdf/SUSHI.pdf
[708] https://webgate.ec.europa.eu/life/publicWebsite/project/details/1817

As noted above, not all restoration activities lead to positive economic, or even environmental outcomes in the short term. This could pose a barrier to their consideration and implementation in some cases. Within agriculture and food production specifically, the lower yields resulting from some practices may impact farmers and rural communities as a whole, as well as interrupting food supply and potentially creating carbon leakages and/or indirect land use change. However, this is likely to be a short term impact as soil restoration can contribute to higher economic returns over time (see Economic section above for details).

There is also a risk in the link between the REST and MON building blocks, and the representativeness of the sample/sampling over the district. Where a district is found to be in poor health, the implication is that all landowners and managers in that district need to take action. But depending on the representativeness of the sample, e.g. where a sample is small/limited, this may drive many more landowners to take action that need to, increasing costs. This could also lead actions to be taken where they could be harmful - for example, ploughing or subsoiling may be listed as restoration measures for compacted sites. If the soil district sample says that the district is unhealthy because of compaction, if all land managers have to use ploughing/subsoiling, this could actually have the potential to further degrade soil health in the district. Some intervening step would be needed to ensure that action is taken in the right places – e.g. additional, more granular testing of land within a district identified as unhealthy, but which would also increase the costs.

Stakeholders have reported that stimulating knowledge sharing will be integral for ensuring restoration can take place within a reasonable timeframe.

Option 2

Option 2 leaves the measures to Member States to define. As such there is a higher risk of inconsistency between Member States, in terms of how they will restore the unhealthy soils. Given the size of the challenge and the costs involved in restoring soils to good health, some Member States may opt for less ambitious definitions of soil health/measures. Indeed, Member States can already implement restoration measures today, but this is not done sufficiently. This risk is greatest for Option 2 where there is no obligation to take measures to restore as such.

This may also result in a lack of consistency/comparability and an uneven playing field across the EU. While some Member States may adopt very stringent and intensive measures, others could go without. A lack of consistency may prevent achieving the obligation of restoring all unhealthy soils by 2050 across the EU, and also be less favourable to land managers who will have to significantly alter their current systems, while others do not.

Links /synergies

Effective implementation of REST requires tracking unhealthy soils are being restored adequately by coherent measures. This will mean monitoring of soils. Hence the MON building block 2 will be critical for ensuring the effective delivery of this Option. As the restoration measures are to be implemented on all unhealthy soils, the definition of a healthy soil influences this (SHSD), and monitoring of soil will identify where action needs to be taken. The REST practices will have to be selected giving consideration to the definition of soil health outlined in the SHSD building block, as they will have to specifically target the aspects of soil health outlined in this definition. Hence the options selected under SHSD (and MON to a certain extent) will have a significant influence on the extent of restoration activities required under REST, and hence the costs and economic, environmental and social benefits.

As stated previously, the impacts of the SSM and REST building blocks could somewhat overlap, in particular where similar measures are instigated, but may differ in the intensity that they are implemented. For example, REST practices may have to be implemented at a higher intensity and/or frequency than SSM to ensure sufficient change to the soil health is achieved to be considered restoration.

Opinions of stakeholders

Opinions received on the obligation to use soil sustainably and apply the principle of non-deterioration are presented in the table below, for each EU MS and major stakeholder type. Information was extracted from written feedback received from MS and other stakeholders.[709] EU MS generally support including definitions of sustainable soil use and non-deterioration in the SHL while stressing that a degree of MS flexibility is necessary considering different soil types, climate and other local conditions. Some however supported the inclusion of obligations, for elements backed by scientific consensus.
an EU obligation but advocate for leeway in programs of measures to be implemented by EU MS.

Table 6-7: Overview of stakeholder input on REST

	Obligation to restore unhealthy soils by 2050	Obligation to adopt a program of measures and revise periodically
Austria	No answer provided	No answer provided
Belgium	No answer provided	No answer provided
Bulgaria	No answer provided	No answer provided
Croatia	No answer provided	No answer provided
Cyprus	No answer provided	No answer provided
Czech Republic	No answer provided	No answer provided
Denmark	No answer provided	No answer provided
Estonia	No answer provided	No answer provided
Finland	No answer provided	No answer provided
France	Support a minimum requirement and timeline to be set at EU-level (national public authority) (CMS)	Support MS flexibility to apply measures (national public authority) (CMS)
Germany	No answer provided	No answer provided

[709] Note that opinions from OPC position papers for civil society and research and academia stakeholders are not synthesized here. Please see the synthesis of stakeholder consultations for more information on the views of these stakeholders.

Greece	No answer provided	No answer provided
Hungary	No answer provided	No answer provided
Ireland	No answer provided	No answer provided
Italy	No answer provided	No answer provided
Latvia	No answer provided	No answer provided
Lithuania	No answer provided	No answer provided
Luxembourg	No answer provided	No answer provided
Malta	No answer provided	No answer provided
Netherlands	Some restoration takes time (e.g., peatlands) (national public authority) (CMS)	Support MS flexibility in applying measures (national public authority) (CMS)
Poland	No answer provided	No answer provided
Portugal	Support minimum requirements at EU level (national public authority) (CMS)	Support MS flexibility in applying measures (national public authority) (CMS)
Romania	No answer provided	No answer provided
Slovakia	No answer provided	No answer provided
Slovenia	No answer provided	No answer provided
Spain	No answer provided	No answer provided
Sweden	No answer provided	No answer provided
Other public authority	Support EU process/framework to restore soils by 2050[710] New regulations should consider already existing systems to avoid bureaucratic burdens.[711]	Support MS flexibility to identify and implement remediation measures (n=2)[712] Support MS flexibility and a risk-based approach[713] Support of EU measures for reduced land use.[714]
Farmers	No answer provided	No answer provided
Foresters	No answer provided	No answer provided
Land owners / land managers	Recovery targets should be set at MS-level; support derogations for degraded soils. EU initiative supported. [715]	No answer provided
Industry (businesses and business associations)	No answer provided	Programme should be a combination of characterization, risk assessment and remediation.[716] Support a flexible approach

[710] Common Forum
[711] Wirtschaftskammer Österreich
[712] Common Forum, Wirtschaftskammer Österreich
[713] Norwegian public authority
[714] Wirtschaftskammer Österreich
[715] NICOLE
[716] Cefic

		(n=2)[717]
Civil society (NGOs)	No answer provided	Interventions for sustainable agriculture and forestry as well as waste management , building and urban planning. Support of a monitoring system.[718]
Research and Academia	No answer provided	No answer provided

Notes: The information are distracted from the source as indicated in brackets. (OPC= Position papers provided via the OPC; CMS=Consultation of Member States; MSEG=Minutes of the soil expert group (#number of meeting added); ESEG=Minutes of the Extended Soil Expert Group 04.10.2022).

Summary assessment against indicators

Setting a target for restoration will carry significant benefits – not least this will set an objective to which the options under the other building blocks should work towards, in particular SSM. A restoration target places an obligation directly on Member States to use soil sustainably and develop a programme of measures to restore all unhealthy soils – this marks a significant improvement in the governance of soils.

This option is also anticipated to deliver a large positive impact on the transition to SSM and overall soil health. However, it is anticipated that the potential benefit under Option 2 is less than that under Options 3 and 4 because where the measures are entirely left up to Member States, there is a greater risk of variance in the content and ambition of these measures (hence also slightly higher risk of implementation).

Adjustment costs of this option will be high given restoration activities will be required which will carry upfront and ongoing costs. However the costs will vary depending on a number of parameters, not least the definition of soil health descriptors and subsequently the size of the area of land deemed 'unhealthy'. Furthermore, adjustment costs under Option 2 are deemed to be slightly lower than under Options 3 and 4, again because where flexibility is left to Member States there may be greater variance in effort between Member States, resulting in some implementing perhaps fewer measures.

The distribution of costs (and benefits) will pose a challenge: some measures may only payback economically over a long time period, and some may not have an economic payback at all (but would deliver substantial societal benefits). This is particularly acute for tenant-landlord land ownership models. Option 2 is slightly more coherent with options under other building blocks, and can fit with options where more flexibility is given to Member States or those that are more prescriptive across the EU.

Table 6-8: Overview of impacts of option 2

Effectiveness	**Impact on soil health**	++	REST practices will deliver significant environmental benefits through improvements to soil health. However, leaving flexibility to Member States risks a race-to-the-bottom, with some potentially taking insufficient action to ensure all soils are restored to good health by 2050. Hence benefit lower than under Option 3
	Information, data	+++	Important benefit of the option – legally binding target to restore

[717] Concawe, Eurometaux

[718] BUND Friends of the Earth

	and common governance on soil health and management		soils to good health and obligation on Member States to defineprogrammes of measures represent significant improvement in governance and management of soil
	Transition to sustainable soil management and restoration	++	Option delivers significant benefit – likely to complement SSM building block in uptake of SSM practices. But high delivery risk curtails benefit relative to Option 3
Efficiency	**Benefits**	++	Impact on soil health key benefit
	Adjustment costs	---	Implementation of REST practices will incur substantial costs of several billions that mostly overlap with SSM. Total cost will be driven by exact set of practices delivered (costs likely to be lower under Option 2 vs 3, but still large)
	Administrative burden	--	Moderate ongoing burden relative to other options, assuming measures will be planned and put in place
	Distribution of costs and benefits	--	Uncertain where costs of implementing REST practices will fall. Landowners and managers will have an important role, but would not capture all the benefits. This is particularly the case for tenant land managers.
Coherence		+	Option coherent with options under other building blocks
Risks for implementation		---	Where the content of the programmes of measures is left to Member States, there is a greater risk of variance in the content and ambition of the measures.

6.1.3 REST - Option 3: Content of programmes of measures defined by Member States with some common criteria

Description of option and requirements for implementation

Option 3 would oblige Member States to restore unhealthy soils by 2050 through programmes of measures and set common minimum criteria for the content of these programmes. The choice of the measures is left to the Member States. A revision of the programmes of measures might be needed based on the monitoring and assessment of soil health.

The option would imply several implementation activities for different actors:

- EU minimum criteria for the content of the programmes of measures for all Member States.
- Member States are responsible for implementing measures, should include all minimum criteria.
- Land managers must implement any measures pertinent to their land and activities within the programmes of measures on if their soil is found to be unhealthy.

The minimum criteria for the programmes of measures are yet to be defined, but may include for example:

- Outcome of the monitoring and assessment of soil health;
- Analysis of the pressures on soil health, including from climate change;
- Measures to apply sustainable soil management practices and restoration measures;
- Legislative, policy and budgetary actions taken or to be taken at national level to improve soil health, including also the systematic approach that will be put in place to identify and manage contaminated sites.

Assessment of impacts

Economic – Option 3

The scale of the impacts could change under Option 3, compared to Option 2, depending on the minimum criteria. If EU criteria would be more stringent than what the Member States would have implemented under Option 2 then there could be greater economic costs where this mandates a greater level of restoration activity across Member States (however, greater activity may not necessarily lead to greater costs as this will depend on a range of variables).

A key difference between the options is with respect to ***administrative burdens.*** Under Option 3, some of the administrative burden of outlining a programme of measures may be alleviated in Member States. Member States are likely to face low levels of administrative burden as 0.1 FTE or EUR 135,000.

Table 6-9: Total administrative burden across REST options

Option number	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-off costs	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 3	29,000	98,000	460,000	1,400,000	-	-	490,000	1,400,000

Note: upfront costs have been annualised over a 20 year period using a discount rate of 3%, as guided in the BR Toolbox

Environmental – Option 3

The environmental impacts of REST directly depend on the specific measures implemented. The impacts of Option 3 will therefore depend on the minimum criteria provided by the EU. These will possibly be similar to the impacts assessed under Option 2, with benefits to Climate (e.g. increased carbon sequestration), Quality of natural resources (e.g. improvements to water storage and nutrient cycling), and Biodiversity (see *REST Option 2 – Environmental*). However, the minimum criteria provided will also assure a minimum level of these impacts achieved across affected areas, which may not have been the case where Member States had no input from the EC.

Social – Option 3

No difference in assessment to those assessed for Option 2.

Distribution of effects

The nature of the distribution of effects will be largely similar to Option 2. A key difference, however, is that the EU will define some common criteria, which may cause the setting of measures within each Member State to become a more labour intensive task.

Risks for implementation

With Option 3, the content of the programmes of measures will be steered by the common minimum criteria. This can provide more consistency between Member States. However, if the EU defines more measures intended for restoration, the greater risk there is that these measures clash with existing policies/initiatives within Member States, and that they have to be generic enough to apply to all Member States and become ineffective due to lack of specificity.

Further to this, the technical feasibility of agreement being reached as to what is the content of the programmes of measures at EU level becomes more of a risk in Option 3 compared to Option 2. Agreement across the EU will require more discussion and debate over what measures are appropriate for implementation across the wider land area, which encompasses diverse soil types and climates across the EU.

Links /synergies

No difference in assessment to those assessed for Option 2.

Summary assessment against indicators

Setting a target for restoration will carry with it a significant benefit, not least this will set an objective to which the options under the other building blocks should work towards, in particular SSM. A restoration target places an obligation directly on Member States to restore unhealthy soils and develop a programme of measures. This marks a significant improvement in the governance of soils.

This option is also anticipated to deliver a large positive impact on overall soil health. It is anticipated that the potential benefit under Option 3 would be greater than Option 2 as less flexibility around the programmes of measures is left to Member States, hence slightly reducing the risk of variance in the content and ambition of these plans across the EU (hence also slightly lower risk of implementation). However, this depends on which and how many criteria or measures are prescribed by the EU as common.

Adjustment costs of this option will be high given restoration activities will carry upfront and ongoing costs. However, the costs will vary depending on a number of parameters, not least the definition of soil health descriptors and subsequently the size of the area of land deemed 'unhealthy'. Adjustment costs under Option 3 are deemed to be higher than under Option 2, again as greater commonality is prescribed across Member States.

Table 6-10: Overview of impacts of option 3

Effectiveness	**Impact on soil health**	+++	REST practices will deliver significant environmental benefits through improvements to soil health. Some implementation risks remain, but overall deemed lower than Options 2 and 4, hence benefits anticipated to be greatest under this option.
	Information, data and common governance on soil health and management	+++	Important benefit of the option – legally binding target to restore soils to good health and obligation on Member States to define programmes of measures represent significant improvement in governance and management of soil
	Transition to sustainable soil management and restoration	+++	Option delivers significant benefit – likely to complement SSM building block in uptake of SSM practices. Given lowest risk of implementation, anticipated to deliver greatest benefit
Efficiency	**Benefits**	+++	Impact on soil health key benefit
	Adjustment costs	---	Implementation of REST practices will incur substantial costs of several billions that mostly overlap with SSM. Total cost will be driven by exact set of practices delivered
	Administrative burden	--	Moderate ongoing burden relative to other options, in particular through need to produce and update the programmes of measures for each Member State (EUR 1m to 5m pa)

	Distribution of costs and benefits	--	Uncertain where costs of implementing REST practices will fall. Landowners and managers will have an important role, but would not capture all the benefits. This is particularly the case for tenant land managers.
Coherence		+	Option fairly coherent with options under other building blocks
Risks for implementation		--	Some risk of variability across Member States remains, but lower than Option 2. Some risk around universal applicability of common criteria, but lower than Option 4, in particular assuming criteria implemented are limited to those where there is confidence they could apply EU-wide.

The distribution of costs (and benefits) will pose a challenge as some measures may only payback economically over a long time period, and some may not have an economic payback at all (but would deliver substantial societal benefits). This is particularly acute for tenant-landlord land ownership models. Option 3 is generally coherent with options under other building blocks, and can fit with options where more flexibility is given to Member States or those that are more prescriptive across the EU.

6.1.4 REST - Option 4: Content of programmes of measures harmonised at EU-level

Description of option and requirements for implementation

Option 4 would fully harmonise the content of the programmes of measures. Harmonised content could mean a stringent and extensive template that needs to be followed and a list of mandatory restoration practices. Harmonisation at this level will likely hold greater positive environmental impacts, but also higher adjustment costs.

The option would imply several implementation activities for different actors:

- The EU is responsible for fully harmonising the content of the programmes of measures and restoration measures. A list of mandatory restoration measures will be included in the legislation that must be implemented on all unhealthy soils across the EU.
- Member States will be responsible to develop and implement the necessary activities/processes outlined by the EU in the fully harmonised programme of measures.
- Land managers must implement any measures pertinent to their land and activities on their soil if it is found to be unhealthy.

Assessment of impacts

Economic – Option 4

A key difference under Option 4 is in the adjustment costs (***public authority budgets).*** Where the EU requires a more ambitious, stringent programmes of measures, this may increase capital and operational expenditure for the responsible parties to implement these measures. However, these will likely be short term costs, as some long-term soil restoration practices could achieve a positive economic payback in the medium to long term, and a more intense REST will only enhance these impacts (see Economic section above).

A further key difference is the additional ***administrative burden*** for the EC to develop a template that fully harmonises the content of the programmes of measures (total upfront in the region of EUR 432,000). There may be a small additional cost to the EC to follow a stringent and extensive template for the programmes of measures, upfront costs of less than 0.5 FTE or EUR 675,000.

Table 6-11: Total administrative burden across REST options

Option number	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-off costs	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 4	33,000	98,000	500,000	1,400,000	-	-	530,000	1,400,000

Note: upfront costs have been annualised over a 20 year period using a discount rate of 3%, as guided in the BR Toolbox

Environmental – Option 4

The key difference with Option 3 is that the programmes of measures will be fully harmonised by the EU, which may increase the scale of the environmental benefits delivered (assuming a more stringent/ambitious approach will be implemented at this level). However, the positive benefits may be also reduced, if the plan is generalised to be applicable across all Member States, and measures become less effective (see risks below).

Social – Option 4

No difference in assessment to those assessed for Option 2.

Distribution of effects

The nature of the distribution of effects will be largely similar to Option 2. In this instance, the EU will have to take a larger role in ensuring the harmonisation across all Member States, so may incur a higher Administrative Burden under this Option.

Risks for implementation

Risks also arise when considering the links with other building blocks. As REST depends upon the implementation of SHSD and MON to identify which soils require restoration, a fully harmonised approach to REST may not be feasible unless the same is taken under SHSD and MON. Developing a fully harmonised programme of measures at EU level will not be possible if each Member State has different definitions of soil health, and/or monitoring systems. Similarly, a risk to full harmonisation of REST may result from a lower option being chosen under SSM. The programmes of measures should complement SSM, however it will be difficult to develop this at EU level if there are different actions carried out with each Member State under SSM Options 2 or 3.

The outcomes of measures that achieve restoration are heavily influenced by soil type, climate, soil conditions, surrounding infrastructure etc. These can render measures ineffective in certain circumstances and in some cases could deteriorate soils further. While a fully harmonised approach will likely result in a more stringent set of measures, as well as a level-playing field for land managers, careful consideration will need to be given to the specific content to ensure that implementing the programmes of measures will actually restore soils. With full harmonisation of the content of measures under

Option 4 there may be some oversight of the nuance of restoration measures described in sections above. Member States may have a better understanding of the economic and environmental pressures of their locality, which could allow for a more adaptable approach to be implemented at this level. However, this level of granularity could be lost with EU wide harmonisation. Furthermore, achieving agreement EU-wide on a common content of programmes of measures could entail greater discussion and therefore longer timeline before measures are able to be implemented.

Links /synergies

No difference in assessment to those assessed for Option 2.

Summary assessment against indicators

Setting a target for restoration will carry with it a significant benefit – not least this will set an objective to which the options under the other building blocks should work towards, in particular SSM (in fact given the overlap with the SSM building block, the broad scoring of the options here is similar to those under SSM). A restoration target places an obligation directly on Member States to restore unhealthy soils through a programme of measures, which marks a significant improvement in the governance of soils.

This option is also anticipated to deliver a large positive impact on the transition to SSM and overall soil health. It is anticipated that the potential benefit under Option 4 is the largest across options under REST because the content of the programmes of measures is fully defined by the EU, hence minimising the risk of variance in ambition of these programmes across Member States. However, greater prescription also carries with it a higher risk as to how far a common contents for a programme of measures can be prescribed for the whole EU. This is a highly technical challenge and there is a risk that either this takes a significant time to develop, impacting on the timelines for implementation, and/or a common criteria is developed which is not universally applicable and risks driving detrimental or inefficient activities in certain districts.

Adjustment costs of this option will be high given restoration activities will carry upfront and ongoing costs. However, the costs will vary depending on a number of parameters, not least the definition of soil health descriptors and subsequently the size of the area of land deemed ‘unhealthy’. Adjustment costs under Option 4 are deemed to be the largest under REST, again as a greater level of commonality across Member States is likely to drive more consistency and ambition in effort to restore soils.

Table 6-12: Overview of impacts of option 4

Effectiveness	**Impact on soil health**	+++	REST practices will deliver significant environmental benefits through improvements to soil health.
	Information, data and common governance on soil health and management	+++	Important benefit of the option – legally binding target to restore soils to good health and obligation on Member States to define programmes of measures represent significant improvement in governance and management of soil
	Transition to sustainable soil management and restoration	+++	Option delivers significant benefit – likely to complement SSM building block in uptake of SSM practices.
Efficiency	**Benefits**	+++	Impact on soil health key benefit
	Adjustment costs	---	Implementation of REST practices will incur substantial costs of several billions that mostly overlap with SSM. Total cost will be driven by exact set of practices delivered

	Administrative burden	--	Moderate ongoing burden relative to other options, in particular through need to produce and update programmes of measures for each Member State (EUR 1m to 5m pa)
	Distribution of costs and benefits	--	Uncertain where costs of implementing REST practices will fall. Landowners and managers will have an important role, but would not capture all the benefits. This is particularly the case for tenant land managers.
Coherence		+/-	Option less coherent with options under other building blocks
Risks for implementation		---	Greater prescription carries with it a higher implementation risk as to how far common content for a programme of measures can be prescribed for the whole EU - risks driving detrimental or inefficient activities in certain districts. Hence higher risk than under Option 3.

The distribution of costs (and benefits) will pose a challenge as some measures may only payback economically over a long time period, and some may not have an economic payback at all (but would deliver substantial environmental and societal benefits). This is particularly acute for tenant-landlord land ownership models. Option 4 is slightly less coherent with options under other building blocks since it may be less consistent to be very prescriptive around the content of the programmes of measures under REST but leave greater flexibility to Member States, say, around the definition of soil health indicators, districts and monitoring programmes.

6.2 Soil remediation (REM)

6.2.1 Overview

Baseline – remediation of contaminated sites

Existing provisions for remediating contaminated land.

Error! Reference source not found.below describes the existing relevant international and EU policies that provide for remediation in the EU. This is further elaborated below.

Table 6-13: Relevant policies to baseline for REM

Policy	Relevant component	Relevance to Restoration/Remediation Measures
Minamata Convention on Mercury	Article 12 (4) Contaminated sites	The Minamata Convention addresses specific human activities which are contributing to widespread mercury pollution. Article 12 (4) establishes that parties should cooperate in developing strategies and implementing activities for remediating contaminated sites.
Industrial Emissions Directive (IED)	Chapter II Provisions for Annex I activities	Article 14 requires Member States to ensure permits for industrial emissions include appropriate requirements to ensure protection of soil (and groundwater). Measures taken to prevent emissions to must be subject to regular maintenance and surveillance. Periodic monitoring of soil in regard to hazardous substances likely to be found on site shall be undertaken (further specified in Article 16). Furthermore, Article 22 requires operators to assess the state of soil contamination after the activity has taken place, and if significant pollution has been caused, the operator shall take the necessary measures to address the pollution. Overall, the provisions prevent the creation of new contaminated sites, therefore reducing the number of sites requiring remediation or risk reduction measures.
Environmental Liability Directive (ELD)	Article 2, Annex II Remedying of environmental damage	The ELD implements the Polluter Pays Principle, placing the burden of remediation costs on the polluter. Article 2 obliges the polluter to take the necessary measures to ensure that relevant contaminants are removed, controlled, contained or diminished so that the contaminated land does not pose any significant risk for human health. This said, when the polluter cannot be identified, contaminated sites remain unaddressed, preventing the legislation from achieving remediation of all soils.

At EU-level, soil contamination is addressed by many pieces of environmental legislation aiming to prevent chemical pollution.[719] These pieces of legislation prevent the creation of new contaminated sites by setting obligations for potential polluters, therefore reducing the need for remediation. The ELD and IED (described above) directly include provisions to undertake remediation as they place remediation responsibilities on polluters. However, the main limitation of the existing legislation is the lack of provisions to remediate historical or orphan contamination or contamination that falls outside the scope of these directives (e.g. caused by activities other than those listed in the annexes of the directives). Where pollution cannot be attributed, there is no EU legal framework for remediating sites. The EU provides funding to support remediation, e.g. through Cohesion Policy or the LIFE programme.

Member State differences in remediation efforts and targets

Across the EU, there are 24 different national policies addressing soil contamination and remediation. The baseline includes non-binding targets and different starting points between Member States. Management efforts vary widely among countries. Some countries are at an advanced stage after decades of identifying and remediating sites. Meanwhile, other countries that have started to address soil contamination more recently must first identify contaminated sites before they can undertake broad remediation activities. This highlights the reliance of these remediation measures on the definition measures described in building block 4.

Differences between the efforts of Member States cannot be quantified or described specifically, because of the lack of defined targets, the lack of monitoring of progress, and/or the lack of reporting. However, this information is critical to understand the baseline and impacts, and so the differences are approximated below. The analysis is based on incomplete and inconsistent data, therefore the true differences between Member States are uncertain.

Most Member States responding to the JRC (2018) questionnaire did not have established targets and milestones for remediating sites,[720] or provided only vague/no answers related to when remediation would likely be achieved.[721] Furthermore, even where targets/estimates for years of completion were provided, these are generally non-binding, with varying levels of ambition/likelihood, and/or only for a subset of contaminated sites. Austria, Belgium, Finland, Hungary, and Sweden have targets to remediate all/most/or highest risk sites by various years up until 2050. It is unclear whether countries are expected to meet these targets.

The number of remediated sites (or sites where RRMs completed) registered by Member States and reported to the JRC varies substantially:[722]

- **Most remediated sites**: The Netherlands (53,000), Germany (36,000); Belgium (7,000); Finland (5,700); France (3,000); Italy (2,900); Denmark (2,000); Sweden (1,900); Czechia (1,200); Luxembourg (1,000).

[719] For example, product-specific pieces of legislation on biocides and plant protection products, waste disposal directives for waste, landfill, mining waste and sewage sludge (see Glæsner et al. (2014) Do Current European Policies Prevent Soil Threats and Support Soil Functions?)
[720] Croatia, Cyprus, Czechia, Italy, Latvia, Luxembourg, Poland, Portugal, and Slovenia.
[721] Bulgaria, Denmark, Estonia, France, Germany, Greece, Malta, Romania, Spain.
[722] EEA (2022) EIONET questionnaire on national contaminated sites. Available: https://www.eea.europa.eu/data-and-maps/data/eionet-questionnaire-on-national-contaminated-sites [Accessed January 2023]

- **Moderate number of remediated sites**: Slovakia (700); Hungary (350); Czechia (250); Austria (200).
- **Fewest remediated sites**: Malta (1); Cyprus (4); Croatia (5); Bulgaria (20); Latvia (44); Poland (73); Portugal (83); Lithuania (96); Estonia (110); Spain (150).
- **Not reported**: Greece; Ireland; Romania; Slovenia; Belgium (Brussels). Between 2011 and 2016, efforts to remediate seemed to decrease in some Member States. Belgium (Flanders), Estonia, Italy, Latvia, and Slovakia reported a reduction in the number of sites under remediation[723]. It is unclear whether this reduction is due to changes in reporting or a reduction in efforts.

Number of sites needing remediation or RRMs

The EEA (2022) estimates that 166,000 sites require remediation across the EU.[724] The uncertainty regarding this number is reflected in building block 4 (see **Error! Reference source not found.**5-3).

Reported sites needing remediation, or potentially needing remediation, per Member State, are provided by the EEA.[725] These data are incomplete and inconsistent, meaning interpretation is limited. For example, the Netherlands has the highest reported number of sites which may need remediation (79,000), but this is likely due to reporting differences, rather than higher needs for remediation, as the Netherlands also has the highest number of sites already remediated, by tens of thousands. Sweden similarly has a high number of sites registered as (potentially) needing remediation, but again has reported far more sites that are already remediated in comparison to other countries. On the other hand, Cyprus reported only 4 sites remediated, and only 3 sites needing remediation, therefore these numbers are likely a significant underestimation.

It is possible that Member States with fewest sites already remediated could have the most sites remaining (see the sub-section above - Malta; Cyprus; Croatia; Bulgaria; Latvia; Poland; Portugal; Lithuania; Estonia; and Spain). Based on this logic, and considering the density of sites per artificial surface area of Member States, the following approximations are made, with noted uncertainty (and keeping in mind the lack of reporting from Romania, Greece, Ireland, Slovenia, and Brussels Capital Region):

- The highest number of sites needing remediation may be in: Croatia, Bulgaria, Poland, Cyprus, Malta, and Spain.
- The second highest number of sites needing remediation may be in: Portugal, Latvia, Austria, Lithuania, Hungary, France.
- The third highest number of sites needing remediation may be in: Estonia, Italy, Slovakia, Czechia, Sweden, and Denmark.
- The lowest number of sites needing remediation may be in: Belgium, Germany, Finland, Luxembourg, and the Netherlands.

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[723] JRC (2018)

[724] EIONET questionnaire on national contaminated sites — European Environment Agency (europa.eu) – taking the number of sites registered as needing, undergoing, or with completed remediation (sum of site status 4a – 6) as a proportion of the total number of registered sites investigated (sum of sit status 3 – 6), multiplied by the upper estimate for number of sites needing investigation (assumed 3.5 million).

[725] EIONET questionnaire on national contaminated sites — European Environment Agency (europa.eu)

Efforts to remediate contaminated sites under the baseline

The EEA (2022) stated that 115,000 CSs had been remediated in the EU by 2016 and estimated a median number of site remediations of 129 sites / Member State / year, and statistical average of 614 sites / Member State / year. Overall, this indicates that total efforts across the EU equate to 3,500 - 16,600 remediated sites per year.

Without intervention, remediation efforts could decrease over time for the following reasons:

- Member States currently making good progress in remediating sites are likely to reduce efforts over time, as the number of contaminated sites needing remediation reduces.
- Member States currently failing to implement remediation measures would not be likely to increase efforts to remediate due to general lack of requirements in existing national and EU laws. If current efforts of these countries continue, a large number of sites would not be remediated over the time horizon.

Given the expected decrease in efforts without intervention, it is assumed that under the baseline, remediation would take place at an average rate of 3,500 sites per year. Over a 25 year time horizon, this would result in the remediation of half of the estimated CSs with unacceptable risks in the EU, failing to achieve a toxic-free environment. This is considered the most likely scenario, however there are large uncertainties regarding the expected rate of remediation over time across the EU.

Remediation techniques

Two key remediation approaches are available to Member States:

- Excavation and ex situ treatment excavation of contaminated waste, such as soil, sludge and debris from a site, involves digging it up for "ex situ" (aboveground) treatment.[726] This technique is frequently used for hot spots', or when the exploitation pressure at the site is high.[727] Ex situ treatment technologies involve the treatment of contaminated soil away from the polluted site. Ex situ techniques entail land farming, biopile, windrow, soil washing, composting, bioreactor, ion exchange, adsorption/absorption, pyrolysis and ultrasound technology.
- In situ treatment technologies: in situ treatment leaves the soil structure intact but reduces the potential migration of contaminants through soil and water systems.[728] In situ treatment includes a wide range of techniques from thermal, physical/chemical, and biological technologies.

The two methods are applied about equally.[729] An alternative approach is excavation and disposal. This involves removal of the contaminated soil from the site and disposal in landfill. Although the contamination is not removed from or destroyed in the soil itself,

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726 https://semspub.epa.gov/work/HQ/401591.pdf

727 Kuppusamy, S., Palanisami, T., Megharaj, M., Venkateswarlu, K. & Naidu, R. 2016. Ex-Situ Remediation Technologies for Environmental Pollutants: A Critical Perspective. In P. de Voogt, ed. Reviews of Environmental Contamination and Toxicology Volume 236;
Suer, P. & Andersson-Sköld, Y. 2011. Biofuel or excavation? - Life cycle assessment (LCA) of soil remediation options. Biomass and Bioenergy

728 Paya Perez, A. and Rodriguez Eugenio, N., Status of local soil contamination in Europe: Revision of the indicator "Progress in the management contaminated sites in Europe" , EUR 29124 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-80073-3 (print),978-92-79-80072-6 (pdf), doi:10.2760/093804 (online),10.2760/503827 (print), JRC107508

729 https://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites-3/assessment/view

the EEA highlights that excavation and disposal accounts for approximately 30% of "traditional" remediation techniques.

The trends in implementation of remediation techniques within and across EU countries remain largely unknown. Only eight countries[730] provided information on the techniques used for remediation to the JRC (2018). It appears that the most common technique (implemented by seven of these countries) is the ex-situ 'dig-and-dump' technique, which involves the excavation and off-site disposal of the contaminated soil[731]. In this context, alternatives involving more sustainable remediation should be encouraged. Defined by SuRF-UK as "the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process", sustainable remediation is currently promoted by private operators[732]. Organisations such as *CL:AIRE* provide training to remediate soil, for instance, for environmental and construction professionals engaged on investigating, assessing, remediating and developing sites that are contaminated with asbestos.[733] The EU is also enhancing this process through the EU-supported ReSoil project. This initiative employs batch-process technology to excavate soil for transportation to the remediation plant where soil is successfully treated and subsequently returned to the excavation site for its re-use.[734]

6.2.2 REM - Option 2: Prioritisation and choice of measures for remediation left to Member States

Description of option and requirements for implementation

This option considers following measures:

- The EU will define a legally binding target for all Member States to reduce and keep the risk of contaminated sites to acceptable levels by 2050 at the latest in line with the EU's zero pollution ambition.
- Member States will need to have a systematic approach or plan in place to reduce and keep the risk of contaminated sites to acceptable levels e.g. through risk reduction or soil remediation activities.

In addition, Option 2 contains the following specific measure to guide implementation:

- Member States would define their prioritisation strategy for their remediation programme to reach the target. There would be no EU common minimum criteria for the content of the programmes of measures. Thus, Member States would be entirely free to decide on the nature and timing of the remediation measures they put in place.

Under this option, the EU would be responsible for legally defining the target for all Member States that to reduce and keep the risk of contaminated sites to acceptable levels by 2050 at the latest. Member States will have to set their own prioritisation strategy of their remediation programme to reach the target. Landowners must implement any

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730 These countries were Denmark, Estonia, Finland, France, Hungary, Luxembourg, Portugal and Switzerland.
731 JRC 2018, p. 77 and 78.
732 https://www.claire.co.uk/sustainable-remediation/about-sustainable-remediation#:~:text=The%20process%20of%20identifying%20sustainable,through%20the%20use%20of%20a
733 https://www.claire.co.uk/events-training/events-training?start=1
734 https://cordis.europa.eu/article/id/413357-sustainable-remediation-technology-for-detoxing-soil

measures pertinent to their land and activities within the programmes of measures on their soil if it is found to pose unacceptable risk.

In response to the OPC, there was a strong agreement across all stakeholder types that there should be legal obligations for Member States to remediate sites identified as contaminated and posing a significant risk to human health and the environment. 81% of all respondents 'totally agreed' this obligation should be put in place, with a further 14% 'somewhat agreeing'. Furthermore, 'totally agree' was the most frequent response across all stakeholder types. In addition, the majority of OPC respondents also 'totally agreed; that Member States should be required, within a legally-binding time frame, to establish and implement a national plan to remediate sites that represent a significant risk to human health or the environment – 72% 'totally agreed' with this obligation, with a further '18%' somewhat agreeing.

Assessment of impacts

Economic

One of the key impacts associated with options under this building block will be the costs associated with implementing risk reduction and remediation actions**.** Remediation costs vary largely depending on the availability of technologies and techniques for remediation, and the type of contaminated sites existing in each Member State. Contaminated sites are costly to manage due to investigation, monitoring, risk assessment and management, and remediation.

Remediation costs can range from €500 to €50 million per site. EY (2013) assume an average cost of €180,000 per site needing remediation, while the JRC (2018) reports a median cost of €124,000, and the EEA apply a cost of €100,000 per site (reflecting typical costs for "small" sites according to EY (2013)).

Assuming a time horizon of 25 years, the intervention could require an average remediation rate of 6,600 sites per year (e.g. €800 million per year rather (or €1,000 million euro in 2023 prices) if an average remediation cost of €124,000 per site is assumed (2013 prices)).

Member States who have made limited remediation progress so far (e.g. Greece, Ireland, Poland, Romania, and Slovenia) will face the highest costs in comparison to the baseline. The EEA estimate that some Member States (unnamed) currently investigate and remediate as little as 20 sites per year,[735] therefore increased costs would be faced by these countries. Overall, the provisions will ensure a fair distribution of spending on remediation, which has, to date, been unequally distributed between Member States.

There will be administrative burdens associated with the REM options, however these are anticipated to be small in particular compared to options under the other building blocks (Indicator 'Administrative burden': '-'). These are presented in the table below. Upfront burden is marginally higher for Options 2 and 3 as all 27 Member States must define prioritisation criteria. These are presented in the table below.

[735] https://www.eea.europa.eu/ims/progress-in-the-management-of

Table 6-14: REM Option administrative burdens

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-off costs	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 2	-	-	91,000	270,000	-	270,000	91,000	540,000

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

SMEs (***Position of SMEs)*** working in "risk activities" could be more vulnerable to additional costs in comparison to larger businesses. For example, large businesses are more likely to have access to other sites in case business activities in a certain location need to cease if the location is identified as a CS, however cessation of activities would likely be very rare. Large businesses may also find it easier to implement and absorb the costs of additional pollution control technologies (which may be expensive).

At the same time, these costly activities have long term economic benefits in terms of ***avoided health costs, regeneration of land (to facilitate economic activity and reduce the strain of land take), and through provision of ecosystem services***. These impacts are described below, and ultimately show that the benefits from soil remediation are of high magnitude, with the largest economic benefits stemming from avoided health costs (billions of euros per year). These economic benefits cannot be fully quantified for several reasons,[736] but are assumed to be larger than costs over the long term. This is in accordance with some studies in the scientific literature,[737] but overall, accurate estimates are lacking, and the basis for the conclusion that benefits would be extensive is set out below.

The economic impacts resulting from the ***health impacts*** of chemicals (see also social impacts below) are of extremely high magnitude, due to the range of chemicals on the market, the range of associated health outcomes, and the range of exposure sources. Studies estimate costs of billions of euros per year due to individual chemicals/ groups of chemicals. For example, phthalates are associated with a range of health outcomes, and the disease burden from endometriosis alone caused by phthalates has been estimated to be over €1 billion annually in the EU.[738] Costs from PBDEs across the EU due to IQ losses and intellectual disability have been estimated to be €10 billion annually across the EU.[739] Furthermore, the EU health burden from lead and methylmercury is estimated to be €47 billion annually.[740] While these specific chemicals are recognised as more toxic

[736] E.g., complicated exposure pathways, challenges in establishing exposure-health outcome relationships of most contaminants, lack of information on the occurrence of all contaminants across soils in the EU, challenges in monetising these impacts, particularly for ecosystem services e.g. with cultural and well-being benefits.
[737] Huysegoms et al. (2017) Friends or foes? Monetized Life Cycle Assessment and Cost-Benefit Analysis of the site remediation of a former gas plant. Science of the Total Environment 619-620.
[738] Milieu (2017) The Study for the strategy for a non-toxic environment of the 7th Environment Action Programme Final Report, EC, DG Environment
[739] Trasande, et al. (2016). Burden of disease and costs of exposure to endocrine disrupting chemicals in the European Union: an updated analysis. Andrology, 4(4), 565–572.
[740] Amec Foster Wheeler et al. (2017) Study on the cumulative health and environmental benefits of chemical legislation. European Commission DG Environment.

than other chemicals, this small number of examples still raises concern regarding the potential scale of total health impacts from the thousands of chemicals present in the EU environment.[741]

No specific estimates for the monetary value of health impacts from soil contamination were identified in the literature. Furthermore, attributing chemical exposure (e.g. human biomonitoring data) and impacts (e.g. health costs) to contaminated sites is challenging, as humans are continually exposed to chemicals from a multitude of different sources. Only some studies directly attribute chemical exposures to soil.[742] However, given the extent of contamination across Europe (166,000 sites needing remediation) and the range of contaminants present on CSs in Europe (e.g. chlorinated hydrocarbons, (polycyclic) aromatic hydrocarbons, heavy metals, phenole, cyanide, polychlorinated biphenols, and pesticides),[743] the overall health impacts, and consequent economic impacts, are anticipated to be of large magnitude. These economic impacts materialise as costs to public and private health industries, lost productivity of individuals suffering illness caused by contaminants, as well as lost earnings to those affected. The full picture of economic costs from contaminants is complex, as some impacts are indirect and far reaching, e.g. IQ loss caused by lead has been associated with increased violence and crime,[744] placing costs on public authorities.

The second type of economic benefit from the remediation measures is the ***regeneration of the value of land***. The costs of not remediating (brownfields) come with a tremendous loss of economic potential (in commercial property tax, in economic development and investment, and in goods and services).[745] Remediating soils can reinstate the economic potential by facilitating economic activities which could not take place otherwise. The value of economic activities susceptible to be performed on remediated soil is estimated to be 1,800 EUR/hectare/year for agriculture.[746] If all CSs were remediated and used for agricultural purposes, economic benefits could reach an average of €11.9 million – €59.4 million per annum[747] (compared to €6.3 million – €31.5 million under the baseline). In total, these benefits would significantly exceed those under the baseline due to the increased rate of remediation and because the benefits are regenerative each year, meaning that benefits would be generated sooner and last for a longer time period.

The regeneration of land value is a critical benefit given that the EU currently faces significant pressure regarding land use. Urbanisation and industrialisation led to 539 km^2/year land take between 2012 and 2018,[748] reflecting the modification of natural areas by development of infrastructure/artificial surfaces. Remediating CSs to allow

[741] The co-occurrence of thousands of chemicals in EU water bodies has been reported for example by van Gils et al. (2020) Computational material flow analysis for thousands of chemicals of emerging concern in European waters. Journal of Hazardous Materials, 397(February), 122655.
[742] E.g. Petit et al. (2022) Human biomonitoring survey (Pb, Cd, As, Cu, Zn, Mo) for urban gardeners exposed to metal contaminated soils
[743] Occurrence is reported in data available through the JRC ESDAC - Soil Contamination - ESDAC - European Commission (europa.eu)
[744] BerBruggen (2021) Lead and Crime: A Review of the Evidence and the Path Forward.
[745] Ding, E. L. (2006). Brownfield Remediation for Urban Health: A Systematic Review and Case Assessment of Baltimore, Maryland. Journal of Young Investigators.
[746] Economic accounts for agriculture - values at current prices - Products Datasets - Eurostat (europa.eu)
[747] This applies a lower estimate for average size of contaminated sites of 1 hectare and an upper estimate of 5 hectares. The true value is unknown. Based on ESDAC data (CSI-015 2011), Member States reported average sizes of PCSs of 1 – 94 hectares, with most estimates below 10 hectares per site. In a 2019 factsheet on potentially contaminated land from the UK government, an average of 0.92 hectares / site can be calculated (300,000 hectares of contaminated land on 325,000 sites).
[748] https://www.eea.europa.eu/data-and-maps/indicators/land-take-3/assessment#:~:text=More%20info-,More%20information,and%20sport%20and%20leisure%20facilities.

development on brownfield, rather than greenfield, sites would be beneficial to sustainable development, as it would reduce degradation of the natural environment (boosting natural capital) and reduce the economic pressures of reduced land availability for development.

Regeneration of land value also causes a ripple effect on the surrounding area in terms of economic benefits. In 2017, Haninger et al. found that remediation of brownfields in the US positively revalued house prices of neighbourhoods by 5 - 15%.[749] In 2022, the similar finding were observed in the Czech Republic, where regenerated brownfields raised the price of properties located within a 500 metres distance by 3.4%.[750] Additionally, remediation can boost local employment, associated with gains in employment capital as a result of upskilling and comprehensive job opportunities.[751] Remediation may also attract new investment and new businesses to the area, developing new economic clusters, and increasing tax revenue for local governments 2 to 7 times more than the public costs invested.[752]

The final type of economic benefit described in this section is the ecosystem services facilitated by remediation. **These ecosystem services provide economic, social and environmental benefits, which are transboundary and should be interpreted in the context of all impact categories, not only economically.**

The table below describes the ecosystem services provided by healthy soils and explains how contamination prevents of hinders these ecosystem services.

[749] Haninger, K., Ma, L., & Timmins, C. (2017). The value of brownfield remediation. Journal of the Association of Environmental and Resource Economists, 4(1), 197-241.
[750] Turečková, K., Martinát, S., Nevima, J., & Varadzin, F. (2022). The Impact of Brownfields on Residential Property Values in Post-Industrial Communities: A Study from the Eastern Part of the Czech Republic. Land, 11(6), 804.
[751] SuRF (2020). Supplementary Report 2 of the SuRF-UK Framework: Selection of Indicators/Criteria for Use in Sustainability Assessment for Achieving Sustainable Remediation.
[752] 2 Sullivan, K. 2017. Brownfields Remediation: Impact of Local Residential Property Tax Revenue, Journal of Environmental Assessment Policy and Management 19(3).

Table 6-15: Ecosystem services provided by healthy soil and how these ecosystem services are prevented by contamination

Ecosystem service	Description of benefits provided	Effects of soil contamination on the ecosystem service
Nutrient cycling	The ability of remediated soil to restore nutrients, maintaining soil fertility.	Contamination leads to an imbalance in functional diversity that hinders nutrient cycling. These imbalances are only expected in case of severe toxicity.
Filtering nutrients and contaminants	The ability of remediated soil to control water quality by filtering contaminants and nutrients.	Contamination leads to changes in the soil properties that control the soil contaminant buffering and filtering capacity, preventing their functioning.
Hydrological control	The ability of remediated soil to store and retain water, hence regulating water runoff and mitigate the impacts of flood and drought events.	While water retention and flood prevention is still possible, once the soil is saturated contaminated soil means runoff water is contaminated and affects wetlands, rivers and lakes.
Water cycling	The ability of remediated soil to move water, affecting the development of the biodiversity present in the soil.	Polluted water will be cycled, killing the organisms in the soil.
Biological pest control	The ability for remediated soil to act as a biological control for pests and harmful diseases.	Changes in soil properties prevent the filtering capacity of soil and decrease protection mechanisms.
Climate control	The regulating services of climate control provided by remediated soil through the sequestration of greenhouse gases	The accumulation of non-decomposed organic material due to soil contamination on the surface of polluted soils affects the ability to sequestrate greenhouse gases, although some species may continue to perform without major changes in nutrient and carbon cycling in the soil.
Recycling of waste	The ability of remediated soil to recycle waste by decomposing organic matter.	The contamination of soil decreases its ability to decompose litter and leads to the accumulation of non-decomposed organic and non-organic materials
Biomass production	The provision of water, physical environment and nutrients by remediated soil, benefitting the production of terrestrial biomass.	Soil contaminants result in physiological changes that significantly reduces biomass. This varies depending on the type of biomass and on the concentration of soil contaminants.
Clean water provision	The ability of remediated soil to filter subterrain water reserves and provide clean water.	Through leaching of contaminants, polluted soils in turn become a source of pollution for groundwater, and for fresh water
Physical environment for fauna and flora	The ability of remediated soil to provide a physical environment for flora and fauna.	Soil contaminants result in physiological changes that may be lethal for some soil-dwelling organisms and plants.
Biodiversity	The ability of remediated soil's ability to provide a habitat for an extensive biodiversity pool.	Soil pollution prevents the survival of multiple species present in soil. It may also lead to the replacement of sensitive species with more tolerant species. The effects depend on the type of concentration of soil contaminants.
Raw materials	Remediated soils can be used to produce raw materials, such as clay, or as a source of minerals for medicine	Cannot act as a source of raw material for medicine, but contaminated soil can be used as an alternative raw material in cement[753].
Heritage services	Remediated soils help maintain ecological, archaeological and geological archives	Pollutants may affect the preservation of ecological, archaeological and geological archives
Cognitive services	Remediated soils provide educational and spiritual activities	Educational and physical activities are usually not undertaken on polluted sites
Recreational services	Remediated soils provide an environment for recreational activities, for example ecotourism	Recreational activities are generally not undertaken on contaminated sites

[753] Recycling contaminated soil as alternative raw material in cement facilities: Life cycle assessment - ScienceDirect

Estimations for the monetary value of many ecosystem services provided by healthy soil have been made in the scientific literature:

- Nutrient cycling has been valued at approximately €79/hectare/year, with estimates ranging between €18/hectare/year and €140/hectare/year.[754]
- The filtering of contaminants and nutrients has been estimated to be valued within the range of €421/hectare/year [755] and €4955 hectare/year,[756] depending on the type of pollutant or nutrient that is filtered.
- Hydrological control has been valued at €23/hectare/year [757]
- Water cycling has been valued at approximately €73/hectare/year, with estimates ranging between €48/hectare/year and €97/hectare/year.[758]
- The ability to act as a biological pest control has been estimated to be valued within the range of €45/hectare/year [759] and €207/hectare/year,[760] depending on the importance of soil's artificial pest control its use.
- Climate control provided by remediated soil, through the sequestration of greenhouse gases, has been valued at €17/hectare/year[761]
- The ability to recycle waste has had reported values ranging between €60/hectare/year and €255/hectare/year.[762]
- Biomass production has been valued at €17/hectare/year.[763]
- Clean water provision has been valued at €24/hectare/year.[764]
- The value of remediated soil's ability to provide a habitat for an extensive biodiversity pool is uncertain. However, the combined value of the species preservation and landscape identity services provided by remediated soil has been estimated at €446/hectare/year.[765] This is used as a proxy for biodiversity.
- The production of raw materials been estimated to be valued within the range of €7 and €113/tonne.[766]

For the heritage, cognitive and recreational services of soil, there is an absence literature attributing an economic value. Additionally, unlike the value of the other ecosystem

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[754] Jónsson, J. Ö. G., & Davíðsdóttir, B. (2016). Classification and valuation of soil ecosystem services. *Agricultural Systems*, *145*, 24-38.
[755]Dominati, E., Mackay, A., Green, S., Patterson, M., 2014. A soil change-based methodology for the quantification and valuation of ecosystem services from agro-ecosystems: A case study of pastoral agriculture in New Zealand. Ecological Economics 100, 119-129
[756] Dominati, E. J., Mackay, A., Lynch, B., Heath, N., & Millner, I. (2014). An ecosystem services approach to the quantification of shallow mass movement erosion and the value of soil conservation practices. Ecosystem Services, 9(0), 204-215.
[757] San, C.C., Rapera, C.L. (2010). The On-site Cost of Soil Erosion by the Replacement Cost Methods in Inle Lake Watershed, Nyaung Shwe Township, Myanmar. J Environ Sci Manag 13, 67-81.
[758] Sandhu, H.S., Wratten, S.D., Cullen, R., Case, B. (2008). The future of farming: The value of ecosystem services in conventional and organic arable land. An experimental approach. Ecological Economics 64, 835-848.
[759] Sandhu, H.S., Wratten, S.D., Cullen, R., Case, B. (2008). The future of farming: The value of ecosystem services in conventional and organic arable land. An experimental approach. Ecological Economics 64, 835-848.
[760] Dominati, E., Mackay, A., Green, S., Patterson, M. (2014). A soil change-based methodology for the quantification and valuation of ecosystem services from agro-ecosystems: A case study of pastoral agriculture in New Zealand. Ecological Economics 100, 119-129
[761] Rodríguez-Entrenaet al (2012). Evaluating the demand for carbon sequestration in olive grove soils as a strategy toward mitigating climate change
[762] Jónsson, J. Ö. G., & Davíðsdóttir, B. (2016). Classification and valuation of soil ecosystem services. *Agricultural Systems, 145*, 24-38.
[763] Porter, J., Costanza, R., Sandhu, H., Sigsgaard, L., Wratten, S. (2009). The Value of Producing Food, Energy, and Ecosystem Services within an Agro-Ecosystem. Ambio 38, 186-193.
[764] Pretty, J.N., Brett, C., Gee, D., Hine, R.E., Mason, C.F., Morison, J.I.L., Raven, H., Rayment, M.D., van der Bijl, G., 2000. An assessment of the total external costs of UK agriculture. Agr Syst 65, 113-136.
[765] Marta-Pedroso et al (2007). Cost–benefit analysis of the Zonal Program of Castro Verde (Portugal): highlighting the trade-off between biodiversity and soil conservation
[766] Jónsson, J. Ö. G., & Davíðsdóttir, B. (2016). Classification and valuation of soil ecosystem services. *Agricultural Systems*, *145*, 24-38.

services which were provided in EUR/ha/year, the value of remediated soil's ability to provide raw materials was provided in EUR/tonne. Hence it was not possible to integrate the value of any of these services within the calculations of total benefit of remediating EU contaminated sites. These ecosystem services provide significant benefits in the context of this land use, meaning the estimated total benefit will be a strong undervaluation. It is also key to note that a majority of the identified studies that did provide an estimated economic value of the ecosystem services provided by soil were not based in EU countries. These values were converted to euros and are used as proxies for what values of these services might be in the EU.

Calculation of the overall value of increased ecosystem services due to remediation is not possible as the above estimates for ecosystem service values were determined in isolation and therefore might be overlapping to some extent. Furthermore, the types of ecosystem services provided by soil depend on the land use. For example, the value of filtering contaminants or acting as a biological pest control only apply when remediated soil is used for agricultural use. Its value would be much lower if the soil was used for the building of human infrastructure. Overall, the value of ecosystem services which could be facilitated by the remediation of soil across the EU is likely to be of the order of several hundreds of euros per hectare per year. These benefits would increase over time as progress is made towards remediation of the 166,000 estimated sites needing remediation across the EU. From 2050 onwards, these benefits would likely be of the order of tens of millions, or potentially hundreds of millions, of euros per year.
Overall, investing in remediating costs to achieve the ecosystem services provided by healthy soil offers a comparative economic advantage to the EU:

- Less agricultural output is wasted because the risk of food contamination through the soil is reduced.
- Remediated soil is more fertile resulting in better agricultural output.
- Water cycling is improved, which results in better agricultural output.
- Remediated soil acts more as a biological control of pest and diseases, resulting in better agricultural output.
- Remediated soil is able to sequestrate more carbon, reducing costs for reaching carbon reduction goals.
- Remediated soil is better able to regulate water runoff, decreasing the impacts of flood, drought and erosion events.
- Remediated soil is better able to control water quality, decreasing the costs of cleaning ground water, lakes and rivers.
- Remediated soil decomposes more waste, reducing the cost of eliminating waste.
- Remediated soil produces more biomass, which results in better agricultural outputs.
- Remediated soil filters more water, providing cleaner water and reducing the cost of making subterranean and surface water fit for human consumption.
- Remediated soil can be better used for producing raw materials, improving economic output.
- Remediated soil provides an environment or recreational activities, creating the opportunity for ecotourism.

Economic – Option 2

Under Option 2, Member States would be able to chose and plan risk reduction measures, which may be less constraining of public budgets, as it could give Member States more time to identify and allocate resources to remediate, and to put measures into place to enforce the Polluter Pays Principle. This would be particularly beneficial for Member States currently lagging in terms of progress in remediation, for example, Malta, Cyprus, Croatia, Bulgaria, and Latvia as requiring more remediation efforts.

Several Member States provided feedback to the targeted questionnaire[767] suggesting that derogations would be critical to ensure feasibility of the measures. For example, Austrian authorities commented out that technical feasibility is often a limiting factor. Denmark authorities explained that they would need additional time beyond 2050 to remediate complex mega-sites for which proper technologies are not yet available.

On the other hand, allowing derogations would also delay the benefits from ecosystem services associated with remediation of contaminated sites. Derogations in Member States which already are making good progress in remediation (e.g. Germany, Finland, and Belgium) may not be justified as they could reduce costs unnecessarily and reduce benefits from ecosystem services.

It is unclear what the need for derogations across Member States is, and what proportion of sites requiring restoration would be derogated under this option. Therefore, it is unclear what the overall economic impacts from derogations would be. The risk of negative impacts could partly be mitigated by as the EU could modify the criteria for derogations based on progress reported by Member States. For example, if limited remediation progress is being made, or derogations are being made too freely, the EU could increase the stringency of criteria.

Benefits from ecosystem services would likely be further delayed by the provision for Member States to define their own work programme. This could allow Member States to delay the remediation of highly contaminated sites because they are more costly.

Environmental

The encouraged remedial and pollution prevention activities would directly improve the ***quality of natural resources***, biodiversity and the environment by reducing the presence of toxic chemicals in soils. Many chemicals (e.g. heavy metals, pesticides, fertilisers, pharmaceuticals) are associated with negative impacts on soil quality[768]. Moreover, eliminating toxic chemicals would prevent the bioaccumulation of harmful substances through the food chain for both animals and humans (see social impacts). Additionally, depending on their physicochemical properties, contaminants can vaporise to air and leach into water sources, and so indirect benefits to ***air and water quality*** may occur in addition to benefits to soil quality.

Toxic chemicals found on contaminated sites are known to negatively impact the living environment, from impacts on individual species and populations to impacts on overall biodiversity ***(Biodiversity, including flora, fauna, ecosystems, and landscapes)***. Therefore, through encouraging remediation and pollution prevention, this option would

[767] Based on the response to the question: *Are there sites which could be derogated by 2050 for technical reasons? If so, would allowing derogations until 2055 resolve this issue? On what basis or parameters should / are sites prioritised for remediation? Would a common approach defined by the EU help you to manage contaminated sites?*
[768] UNEP (2019) Global chemicals outlook II

positively impact biodiversity, including flora, fauna, ecosystems, and landscapes. Long-term interactions between some contaminants and biodiversity are uncertain,[769] therefore impacts could potentially be more beneficial than expected based on the current state of knowledge. Environmental ecosystem services expected are described in the above section on economic impacts.

On the other hand, the common use of the dig and dump technique could have negative effects on the environment. Member States noted that this technique, due to its lack of circularity, is not sustainable and therefore should be limited.[770]

Encouraged remedial and pollution prevention activities could positively impact ***climate change*** mitigation in several ways. For example, there is evidence[771] that pollution reduces the capacity of soil to absorb carbon dioxide.[772] However, the number of studies validating this impact is limited. Furthermore, biological remediation involves phytoremediation, which entails using production of biomass to remediate soils. This can lead to the storage of significant amounts of carbon dioxide, however, the final balance would depend on the use of the biomass. Overall, a positive impact on climate change mitigation could be expected, with some uncertainty.

Environment – Option 2

Environmental benefits from Option 2 would be expected to be of a lower magnitude than in Options 3 and 4. Given the flexibility offered in prioritisation and planning, there is a risk that some Member States will decide to avoid economic costs in the short and mid-term, leaving the majority of the remediation work for the last years before 2050. Furthermore, Member States could choose to remediate less costly sites first, leaving the larger and more contaminated sites untreated for a longer period of time, so that they continue to harm the environment. In addition, some Member States may decide to derogate from the 2050 deadline a significant quantity of CS, maintaining a large area of contaminated soils. The extent to which Member States will seek derogations for CS is uncertain at the time of writing, and therefore the extent to which derogations will detriment the environmental benefits is not clear.

Full flexibility for Member States to define their planning for remediation and implement derogations could be harmful for the environment if due to excessive costs, a large proportion of contaminated soils are left unaddressed.

Social

Contaminated soils threaten the health of EU citizens and workers, and therefore the measures under this building block would have large benefits to human health, ensuring a high level of human health protection in line with Article 35 of the EU Charter of Fundamental Rights. This benefit cannot be quantified because the health issues associated with contaminated soils are not fully characterised (e.g., due to a lack of comprehensive assessments of most soil contaminants and exposure), however, a large magnitude is assumed, given that the limited studies available indicate that at least

[769] Grifoni et al. (2022). Soil Remediation: Towards a Resilient and Adaptive Approach to Deal with the Ever-Changing Environmental Challenges

[770] Spain and Portugal, Working paper for the Soil Health Law: contaminated sites

[771] Xu et al. (2020) Changing soil carbon: influencing factors, sequestration strategy and research direction

[772] General pollution is associated with negative impacts on carbon absorption, while nitrogen addition and chemical fertilisers were positively associated with carbon absorption).

200,000 – 800,000 deaths globally per year can be attributed to soil pollution.[773] Furthermore, globally, the number of deaths caused by soil pollution is increasing.

The benefits of remediating CSs for human health can be illustrated by considering the adverse effects caused by a number of key pollutants often present on CSs.

Table 6-16: Health impacts associated with harmful substances present in CSs

Harmful substance present in CSs	Adverse effects
Lead	Lead is one of the most studied contaminants commonly found on CSs, and is associated with hypertension, renal failure, cardiovascular disease, stroke, and cognitive impairment.[774] Effects have been observed at all levels of exposure, leading to the conclusion that there is no safe level of exposure to lead. The neurodevelopmental effects of lead on EU citizens can cause societal level impacts, for example through increasing the risks of antisocial and criminal disorders, decreased school performance, decreased economic productivity.
Asbestos	Asbestos fibers present in CSs can be inhaled by humans in the sites' surrounding areas. Exposure to asbestos is associated with shortness of breath, persistent dry cough, chest tightness or pain, and lung cancer and mesothelioma.[775]
Methylmercury	In CSs that contain methylmercury, humans surrounding the sites are at risk of inhaling the toxic substance. The Inhalation of methylmercury vapors is associated with chemical pneumonia, respiratory distress, respiratory failure and acute respiratory syndrome.[776]
Organophosphates	Organophosphates are often present due to the use of organophosphate pesticides. Human exposure to organophosphates can cause depression, loss of appetite, disorientation, loss of memory, anxiety, confusion, headaches, nausea, weakness, diarrhoea, vomiting and personality changes.[777]
Polybrominated diphenyl ethers (PBDE)	PBDEs are present in contaminated soils can be inhaled by humans breathing air or swallowing dust in surrounding areas to the sites. PBDEs are endocrine disruptors, altering the normal hormone functioning. Exposure to PCBEs is associated with impaired cognitive development (comprehension, memory), impaired motor skills, increased impulsivity, and decreased attention and testicular cancer.[778]
Phthalates	Phthalates are generally present in CSs near manufacturing facilities. Phthalates are endocrine disruptors i.e. human exposure to phthalates leads to harmful interference with the reproductive, neurological, and developmental systems.[779]
Bisphenol A	Bisphenol A is a toxic substance that is commonly found in CSs. Human exposure to Bisphenol A is associated with neurotoxicity, which has negative effects on the activity and structure of the nervous system, which may result in autism, obesity, attention deficit disorder, intellectual disability and reduced IQ, or cerebral palsy[780].

Various studies have explored and highlighted the health risks of living close to CS. For example, one study found that communities with large amounts of brownfield land (in England) had poorer health outcomes.[781] For instance, increased residential proximity to CS with polychlorinated biphenyls (PCB) is linked with higher rates of low-birth-weight infants.[782] Humans are exposed to soil via three common pathways: oral (ingestion), respiration and skin absorption. Eight of the 10 pollutants of concern according to WHO can occur in soil, with deep impacts on human health: carcinogenicity (As, asbestos and dioxins), neurological defects and lower IQ effects (As and Pb), kidney disease (Pb, Hg and Cd) and skeletal and bone diseases (Pb and fluoride). Moreover, the presence of organic pollutants in soils can accumulate in human tissues, resulting in harmful health effects in the long term.[783] In 2013, in the frame of the SENTIERI Project, researchers

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773 Landrigan et al. (2017) The Lancet Commission on pollution and health.
774 Ibid.
775 Kettunen et al., (2017) Asbestos-associated genome-wide DNA methylation changes in lung cancer.
776 Diez (2009). Human health effects of methylmercury exposure
777 Fallon Nevada: FAQs: Organophosphates | CDC HSB
778 Polybrominated Diphenyl Ethers (PBDEs) | ToxFAQs™ | ATSDR (cdc.gov)
779 Phthalates and Their Impacts on Human Health - PMC (nih.gov)
780 GrandJean and Bellanger (2017) Calculation of the disease burden associated with environmental chemical exposures: application of toxicological information in health economic estimation.
781 https://www.dur.ac.uk/news/newsitem/?itemno=20467
782 Baibergenova, A., Kudyakov, R., Zdeb, M., & Carpenter, D. O. (2003). Low birth weight and residential proximity to PCB-contaminated waste sites. Environmental health perspectives, 111(10), 1352-1357.
783 Siebielec, G., Suszek-topatka, B., & Maring, L. (2016). The impact of soil degradation on human health. Science, 7, 374-392.

observed increased lung cancer and respiratory disease risk in sites hosting refineries and petrochemical plants, and an exposure-disease association between pleural neoplasm mortality and asbestos was confirmed in sites with documented presence of asbestos.[784] Thus, remediating contaminated soils will have a positive impact on public health via avoidance of exposure to harmful chemicals via water, crops, and air ***(Public health & safety and health systems)***. This could occur both through a reduction in occupational exposure (where workers carry out activities close to (or on) CS), and through a wider reduction in risk to local populations who are at risk of exposure to the pollutants.

The health benefits of remediation would largely be reaped by children, as they are more vulnerable to the effects of soil contamination because they play close to the ground and have tendencies for oral exploratory behaviour.[785]

Job creation would be expected from increasing the requirements to investigate and remediate contaminated sites, bringing positive social impacts. Based on the estimated additional cost to remediate CS, it is estimated that this could lead to a direct employment effect of an additional 8,200 FTEs on an ongoing basis. There will also be additional indirect and induced employment effects as the impacts ripple through the economy. Further detail of the approach and results to estimating employment effects is presented in the section on 'quantification of employment impacts'.

Social – Option 2

As noted above, full flexibility for Member States to plan remediation and seek derogations would be expected to delay remediation actions in some instances. This would decrease the human health benefits generated by the intervention, compromising the protection of human health from hazardous chemicals to some degree.

Distribution of effects

Preventing the contamination of soils would stop the deterioration of a non-renewable source, avoiding consequences on all generations. Furthermore, as soil contamination often results from persistent organic pollutants, which can accumulate in soils over years, negative health effects from exposure due to leaching into water sources, uptake by crops, and volatisation into air, may only be realised many years after the contamination event. This option would therefore reduce this inter-generational negative impact on human health.

There will be variation in the costs of this option between Member States. Countries with more significant costs and benefits are likely to be those with the highest number of contaminated sites with unacceptable risks and lowest number of already remediated sites.

Within each Member State, exactly where the remediation costs would fall is uncertain and will depend on the method of implementation by each Member State. In the first instance, the obligation to remediate sites is placed on Member States, and as such this is where the costs are allocated. Currently, an estimated 43% of current remediation

[784] SENTIERI project is a national project developed to evaluate the health profile of populations residing in the Italian sites of national interest for environmental remediation-National Priority Contaminated Sites (NPCS): Pirastu, R., Pasetto, R., Zona, A., Ancona, C., Iavarone, I., Martuzzi, M., & Comba, P. (2013). The health profile of populations living in contaminated sites: SENTIERI approach. Journal of Environmental and Public Health, 2013.

[785] Landrigan et al. (2017) The Lancet Commission on pollution and health.

expenditure comes from public budgets.[786] There is currently high variance in the share between public and private spending on remediation between Member States.

The economic sectors expected to bear the majority of these costs encompass those undertaking polluting activities. In Europe, the leading sources of local contamination are industrial activities, waste treatment and disposal, and oil and chemicals storage.[787] Other sectors which may be responsible for contamination (depending on the activities and risk management measures being implemented) include mining, military activities, nuclear operations, transport, and agriculture.[788] In line with the polluter pays principle and the Environmental Liability Directive (2004/35/EC), it may be expected that at least some of these costs would be borne by these sectors, however, it is not clear to what extent the polluter pays principle can be applied, e.g. in the case of historical or orphan pollution.

There may also be a trend in the location of stakeholders affected. Many (but not all) CS are likely to be located in urban or semi-urban locations. As such, where the costs of remedation are shared with private actors, many will fall in the first instance in these areas. That said, in many cases a single CS will be one site in a wider portfolio, and the costs will accrue to the over-arching business owner, who may spread these costs across its portfolio. There may also be a spatial trend to the distribution of benefits. Some will accrue to the private sector owners e.g. increase in value of restored land (although as for the costs, these might not necessarily fall to urban areas). There will also be other benefits for broader businesses locally – e.g. a reduction in costs of treatment of surface water, groundwater or drinking water contaminated through the soil. More widely, citizens (in particular those living locally) could benefit through improved health, food and water security for the present and subsequent generations. Landowners would also benefit in the long term, as they would preserve the fundamental qualities of the soil where they develop their economic or leisure activities, ensuring productivity and safety.

Risks for implementation

Option 2

Depending on the action and circumstances of each Member State, the flexibility provided through this option could either facilitate compliance with the target and keep the risk of contaminated sites to acceptable levels by 2050 at the latest or, on the contrary, incentivise delaying the majority of the remediation progress to the last years, leading to high (and potentially infeasible) remediation costs before the final deadline for derogations, risking achievement of the objectives of the intervention, and ultimately the EU's ambition for a toxic-free environment.

This Option may not fully address the uneven playing field among Member States, as different paces of progress in remediation would be expected between Member States.

Links /synergies

The scale of remediation benefits is highly dependent on the implementation of building block 4. Without the identification of contaminated sites, no remediation actions can be taken and geographic disparities may continue. The proportion of unidentified contaminated sites would not be remediated, and therefore the REM target to remediate contaminated soils by 2050 could not be met.

[786] JRC 2018
[787] https://www.eca.europa.eu/Lists/ECADocuments/SR21_12/SR_polluter_pays_principle_EN.pdf
[788] JRC (2018), p. 9

Opinions of stakeholders

Opinions received on the obligation to remediate contaminated sites are presented in the table below, for each EU MS and major stakeholder type. Information was extracted from written feedback received from MS and other stakeholders.[789] EU MS who provided feedback through these channels advocated for the possibility to grant derogations to the remediation obligation as well as for sufficient leeway in implementation.

Table 6-17: Overview of stakeholder input on REM

	Obligation to remediate contaminated sites
Austria	No answer provided
Belgium	No answer provided
Bulgaria	No answer provided
Croatia	No answer provided
Cyprus	No answer provided
Czech Republic	No answer provided
Denmark	No answer provided
Estonia	No answer provided
Finland	No answer provided
France	Support derogations (national public authority)
Germany	No answer provided
Greece	No answer provided
Hungary	No answer provided
Ireland	No answer provided
Italy	Support differentiating remediation objectives between land use types
Latvia	No answer provided
Lithuania	No answer provided
Luxembourg	No answer provided
Malta	No answer provided
Netherlands	All remediation not feasible by 2050; some derogations needed (national public authority)

[789] Note that opinions from OPC position papers for civil society and research and academia stakeholders are not synthesized here. Please see the synthesis of stakeholder consultations for more information on the views of these stakeholders.

Poland	No answer provided
Portugal	Support minimum requirements at EU level (national public authority)
Romania	No answer provided
Slovakia	No answer provided
Slovenia	No answer provided
Spain	No answer provided
Sweden	No answer provided
Other public authority	Support derogations based on feasibility[790] Remediation not always possible[791]
Farmers	No answer provided
Foresters	No answer provided
Land owners / land managers	Recovery targets should be set at MS-level; support derogations for degraded soils. EU initiative supported.[792]
Industry (businesses and business associations)	Derogations should be granted when efficient technologies unavailable, costs are disproportionate or sustainable remediation is impossible.[793] Support for derogation for soils providing essential services and naturally unhealthy soils; against mandatory remediation[794] Remediation should focus on risk-reduction, complete remediation not always realistic[795]
Civil society (NGOs)	Regreening of unused sealed areas.[796]
Research and Academia	No answer provided

Summary assessment against indicators

This building block would have significant benefits for the environment, human health, and sustainable development, however, economic costs associated with remediation are anticipated to be high. Option 2 allows derogations for specific sites where particular criteria are met. Again, the impact of this will depend on what criteria for derogation are

[790] Common Forum
[791] Norwegian public authority
[792] NICOLE
[793] Cefic
[794] Concawe
[795] Eurometaux
[796] BUND Friends of the Earth

set, and how many sites are granted a derogation. Either way, the presence of a derogation inherently reduces implementation risk under Option 2 for technical and economic reasons, as Member States have additional time to remediate sites that prove more challenging. However, allowing additional time to comply also increases the environmental and human health risks that CS pose.

Table 6-18: Overview of impacts of option 2

Effectiveness	**Impact on soil health**	++	Remediating contaminated sites delivers a range of environmental benefits, not least reducing presence of toxic substances in soil. Derogation will reduce risks for Member States, but may also lead to fewer sites being restored by 2050, leading to lower benefits relative to Options 3 and 4.
	Information, data and common governance on soil health and management	+++	Option places an obligation on Member States to remediate contaminated sites, hence delivering large improvement in governance
	Transition to sustainable soil management and restoration	++	Remediating contaminated sites leads to improvement in sustainable soil management, but with derogation function, benefits anticipated to be lower relative to Options 3 and 4.
Efficiency	**Benefits**	++	Improvement in soil is key benefit under option
	Adjustment costs	---	Remediation costs per site vary widely, and estimating total costs is uncertain, but likely to be large (but lower than under Options 3 and 4).
	Administrative burden	-	Small additional administrative burden to organise prioritisation of sites (< EUR 1m upfront and ongoing)
	Distribution of costs and benefits	+/--	Uncertain precisely where these adjustment costs would fall. Historically remediation costs have fallen on both public and private budgets. Member States with higher levels of CS will incur greater costs.
Coherence		+	Option coherent with all options under REM.
Risks for implementation		+/--	Flexibility given to Member States brings risk of inconsistency in approach, which may lead to delay in remediation and achievement of environmental benefits. Potential for derogations reduces risk for Member States, but introduces an additional risks that fewer sites may be restored by 2050.

6.2.3 REM - Option 3: Derogation of CS with acceptable risks and Prioritisation for remediation defined by Member States

Description of option and requirements for implementation

Similar to Option 2, under Option 3, Member States would define their prioritisation strategy of their remediation programme to reach the target, and allow derogations based on the same reasons. However, in this option Member States should aim to reduce contaminant loads if the risk is considered unacceptable. Other risk reduction measures than remediation should be avoided.

Assessment of impacts

Economic – Option 3

The economic impacts of Option 3 are expected to be higher than those under Option 2. Favoring remediation or reduction of contaminant loads over other risk reduction measures would increase costs to some degree as they would require Member State efforts to meet a minimum standardEconomic benefits would also be higher since remediation approaches are in general more expensive. The expected administrative burdens are estimated in the table below.

Table 6-19: REM Option administrative burdens

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-off costs	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 3	-	-	91,000	270,000	-	270,000	91,000	540,000

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

Environmental – Option 3

Option 3 would generate environmental benefits of a greater magnitude than Option 2, because as mentioned above, a higher rate of remediation and generally more effective work programmes would be expected.

Social – Option 3

Option 3 would generate social benefits of a greater magnitude than Option 2, because as mentioned above, a higher rate of remediation and generally more effective work programmes would be expected.

Distribution of effects

The distribution of effects would be the same as Option 2, although Member States needing to adapt existing plans would face higher costs than under Option 2. For frontrunners such as Austria or the Netherlands, which may be close to finishing their remediation process, it may not cause much burden. On the other hand, Member States which recently developed their programmes of measures or are not far in the implementation process (the majority of them) would have to alter them substantially, impacting their initial planning heavily. Finally, it can be expected that it would facilitate the legislation and implementation process for those Member States lacking an overarching soil protection act, e.g. Cyprus, Ireland, Poland, and Portugal.

Risks for implementation

Based on the responses to the targeted questionnaire[797], it appears that Member States which already have a remediation programme in place prefer to maintain their prioritisation and planning strategy (Austria). In contrast, others without a developed programme would rather prefer having further guidance in the form of an EU approach (Slovakia).

Links /synergies

The links and synergies are the same as described in the previous section.

Summary assessment against indicators

Table 6-20: Overview of impacts of option 3

Effectiveness	**Impact on soil health**	+++	Remediating contaminated sites delivers a range of environmental

[797] Based on the response to the question:

			benefits, not least reducing presence of toxic substances in soil. Given risks are lowest for this option, benefit achieved anticipated to be greatest.
	Information, data and common governance on soil health and management	+++	Option places an obligation on Member States to remediate contaminated sites, hence delivering large improvement in governance
	Transition to sustainable soil management and restoration	+++	Remediating contaminated sites leads to improvement in sustainable soil management. Some implementation risk, but benefits anticipated to be highest under this option.
Efficiency	**Benefits**	+++	Improvement in soil is key benefit under option
	Adjustment costs	---	Remediation costs per site vary widely, and estimating total costs is uncertain, but likely to be large (less than Option 4, and higher than Option 2).
	Administrative burden	-	Small additional administrative burden to organise prioritisation of sites (< EUR 1m upfront and ongoing)
	Distribution of costs and benefits	+/--	Uncertain precisely where these adjustment costs would fall. Historically remediation costs have fallen on both public and private budgets. Member States with higher levels of CS will incur greater costs.
Coherence		+	Option fairly coherent with all options under REM.
Risks for implementation		-	Flexibility given to Member States brings risk of inconsistency in approach, which may lead to delay in remediation and achievement of environmental benefits (but risk lower than Option 2 as derogations only allowed where risks are acceptable). But flexibility allows Member States to capture national and location specific factors which would also allow them to optimise remediation plans.

6.2.4 REM – Option 4: Prioritisation and planning of remediation defined at EU-level

Description of option and requirements for implementation

Under Option 4, the EU would define the prioritisation criteria and the planning of the remediation programme of Member States, thus, remediation would be fully harmonised based on EU common criteria with strict common intermediate targets for progress. Remediation should be favored over other risk reduction measures. No derogations would be permitted.

Assessment of impacts

Economic – Option 4

Under Option 4, there would be no derogations of any sort, and therefore, annual remediation costs would be higher than under Options 2 and 3. Simultaneously, this faster rate of remediation would lead to ecosystem services being reaped faster. Member States would have to comply with an EU common plan and select remediation measures from a mandatory list, which may be more costly than plans and measures Member States would choose to implement otherwise. Additionally, the administrative burden would be significantly higher due to the obligation to fill in the EU based templates to ensure compliance with the common plan.

On the other hand, this may ease the costs for Member States that still need to design or implement a plan, as they may be able to follow a program the EU has prepared for them. Additionally, the risk that Member States could delay more costly remediation actions would be mitigated, as Member States will have to comply with intermediate targets.

Table 6-21: REM Option administrative burdens

	EC - One-off	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing

	costs				off costs			
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 4	17,000	-	-	-	-	-	17,000	-

Note: upfront costs have been annualised over a 20-year period using a discount rate of 3%, as guided in the BR Toolbox

Environmental – Option 4

Option 4 would be likely to yield environmental benefits of the greatest magnitude among all options. Member States would have to act according to the EU common plan without having the possibility of introducing any sort of derogations. Remediation would be ensured across time in a steady pace across Member States. Providing the EU with responsibility for defining remediation plans would mean this option is more likely to achieve the objectives of the intervention, as the provision of a plan by the EU would support those Member States who currently lack a work programme for remediation and would prevent Member States from delaying action.

On the other hand, the lack of derogations could spread Member State efforts over a larger number of sites, which could redirect some efforts from sites with higher risks to humans and the environment to those with lower risks (e.g. sealed and heavily modified sites). This could compromise the environmental benefits in comparison to Options 2 and 3, however, this effect is expected to be less significant than the benefits from an EU common plan.

Social – Option 4

As described above, Option 4 would be most likely to achieve the objectives of the intervention, therefore social benefits would likely be highest.

Distribution of effects

The distribution of effects would be Option 3, although the difference in burden exacerbated as Option 4 would be more likely to trigger the need for Member States to change their existing plans.

Risks for implementation

Option 4 ensures full EU harmonisation, establishing EU level prioritisation criteria. Depending on how the actual EU plan is designed, such list could represent a significant policy challenge, since the composition of every Member State’s CS and PCS has its own particular characteristics based on geographical, economic and historical reasons. It would provide a clear path for Member States to remediate sites, however, this could lead to undesirable results, where national and local particularities are not adequately taken into account. It would provide a level playing field for Member States but potentially at also a less efficient solution, as it would be more costly due to added administrative burden. EU prioritisation criteria may encompass excessively rigid actions, which conflict with national and regional regulations. Moreover, setting of time-bound (intermediary and final) targets could be possible only for a stabilised list of sites identified as priority sites by Member States, as registers are rather dynamic

Links /synergies

Same as the other options, however, option 4 is marginally less coherent with options under other building blocks.

Summary assessment against indicators

Table 6-22: Overview of impacts of option 4

Effectiveness	**Impact on soil health**	+++	Remediating contaminated sites delivers a range of environmental benefits. Implementation risk exists, but all sites must be remediated by 2050, hence benefits anticipated to be large.
	Information, data and common governance on soil health and management	+++	Option places an obligation on Member States to remediate contaminated sites, hence delivering large improvement in governance
	Transition to sustainable soil management and restoration	+++	Remediating contaminated sites is part of a transition to more restoration. Some implementation risk, but benefits anticipated to be large under this option.
Efficiency	**Benefits**	+++	Improvement in soil is key benefit under option
	Adjustment costs	---	Remediation costs per site vary widely, and estimating total costs is uncertain, but likely to be large (higher than Options 2 and 3).
	Administrative burden	-	Small additional administrative burden to organise prioritisation of sites (< EUR 1m upfront and ongoing)
	Distribution of costs and benefits	+/--	Uncertain precisely where these adjustment costs would fall. Historically remediation costs have fallen on both public and private budgets. Member States with higher levels of CS will incur greater costs.
Coherence		+/-	Option less coherent with all options under REM (i.e. Option 2).
Risks for implementation		--	Full EU-wide harmonisation presents a risk that national and local particularities are not adequately taken into account in the prioritisation of sites, leading to potentially inefficient remediation in some cases.

7 LAND TAKE (LATA)

7.1 Overview

7.1.1 Building block outline

As foreseen in the Soil Strategy, the following building block seeks to establish a net land take definition (LATA 1) and consider approaches for the monitoring and reporting on progress towards the "no net land take" target(s) and the implementation of the "land take hierarchy" (LATA 2).

7.1.2 Problem(s) that the building block tackles

Land take (the increase in artificial areas at the expense of rural areas and of natural areas such as parks and open spaces in cities)[798] can contribute to unhealthy soils as practices such as soil sealing (the loss of soil functions due to the covering of soils by buildings, construction and layers of (partly) impermeable artificial material)[799] leading to irreversible loss of all soil ecosystem services (***main problem in the Intervention Logic***). Establishing a definition or technical standard for land take and obliging monitoring would assist in further data collection and formation of a common governance structure on monitoring land take across the EU (***sub-problem A in the Intervention Logic***).

[798] EEA (2021) Land take and land degradation in functional urban areas
[799] ibid

Currently, the definition of land-take itself and the processes it involves, in addition to assessment methodologies, are not standardised nor aligned between Member States. At the EU-level, monitoring of net land take (currently conducted by the EEA through Corine Land Cover (CLC) maps) cannot currently identify changes below 5 hectares.[800] Given the limitations of EU-level monitoring, national data sources are often utilised to gather more detailed data, yet the definitions and assessment methodologies vary significantly. These inconsistencies can inhibit the development of comparable data and enable an accurate oversight of land take trends at the EU-level.

7.1.3 Baseline

As described in annex 8, substantially more land has been taken in the EU-27 in recent times than land return/recultivation. Between 2012-2018, 301,300ha of net land take is calculated as taking place in the EU-27+UK, or 11.5m^2 per capita (2018 population). Land take during this period affected arable land in absolute terms (169,401ha) the most.[801]

In relation to monitoring, although all Member States monitor land take,[802] few Member States have regular reporting frameworks, quantitative policy targets, or specific definitions of what constitutes 'net' land take.[803] Furthermore, very few Member States monitor the status of soil sealing.[804] The table below outlines EU and Member State's targets in relation to land take and soil sealing.

[800] Copernicus (2022) CORINE Land Cover. Available at: https://land.copernicus.eu/pan-european/corine-land-cover
[801] EEA (2021) Land take and land degradation in functional urban areas
[802] EEA (2022) Soil monitoring in Europe Indicators and thresholds for soil quality assessments. https://www.eea.europa.eu/publications/soil-monitoring-in-europe-indicators-and-thresholds
[803]

gives an overview of land take definitions provided by Member States as part of targeted consultations
[804] EEA (2022) Soil monitoring in Europe Indicators and thresholds for soil quality assessments. https://www.eea.europa.eu/publications/soil-monitoring-in-europe-indicators-and-thresholds

Table 7-1: EU and Member State definitions and policies relating to land take and soil sealing

Member State	Land take definition	Policy	Target
EU	-	EU- 7th EAP and the EU Roadmap to a Resource Efficient Europe	'No Net Land Take' in the EU by 2050
AT	"Taken" means land that has been altered and/or built on by human intervention for settlement, transport, leisure, recreation and waste disposal purposes and are therefore no longer available for agricultural and/or forestry production and as a natural habitat. In principle the use of forest soil for purposes other than those of forest cultivation is defined as "clearing" ("Rodung")	Austria- Austrian Strategy for Sustainable Development	Reduce net land take to 2.5ha/day in 2030
BE	-	Belgium (Flanders)- Flanders Spatial Plan	Decrease net land take to: 6ha/day 2016; 3ha/day 2025; 0ha/day 2050
FR	The consumption of natural, agricultural and forest areas is understood as the actual creation or extension of urbanised areas on the territory concerned[805]	LAW no. 2021-1104 of August 22, 2021 on striving climate change and strengthening resilience	Net Zero Artificialisation in 2050 with a reduction of half of the consumption of natural, agricultural and forest areas within 10 years compared to the actual consumption observed over the last ten years
DE	Land (re)use (land consumption) is the non-material soil pollution caused by anthropogenic influences on soil quality. The broadly defined term includes all changes to the natural soil profiles and groundwater conditions caused by construction measures, fragmentation effects caused by linear infrastructures, climatic deterioration caused by building development, and impairment of the landscape.[806]	Germany- German Sustainable Development Strategy	Reduce land take for settlements and traffic infrastructure to less than 30ha/day by 2030
LU	Land take = Voluntary or involuntary change in land use of a soil, from a land use class considered as non-artificialised to a land use class considered as artificialised. This land use change must be concretely observed in the field and must be independent of the administrative aspect of the land use change, which does not reflect reality sometimes. On the opposite, restoration can be defined as: Voluntary or involuntary change in land use of a soil from a land use class considered as artificialised to a land use class considered as non-artificialised. Artificialisation = Voluntary or involuntary human actions on a soil induced by a land use change or human operations that cause significant changes in its properties, which lastingly jeopardise its ability to provide one or more ecosystem services. Artificialisation is characterised by a degree of artificialisation (which can be expressed in %, e.g. from 0% to 100% artificialised) that is directly linked to the ability of a soil to provide natural ESs. The rate of artificialisation of a soil can increase or decrease over time depending on the activities and management practices that are applied to it.[807]	Luxembourg- Luxembourg Spatial Planning Program	Reduce land consumption to 0ha by 2050
SK	-	Slovakia- Act on Protection and Utilisation of Agricultural Soil	Protect 30% of agricultural soils from land take (pay fee if cannot be avoided)

[805] NAF Consumption - Article 194 III 5°

[806] KBU (2009) Geschäftsstelle der KBU - Kommission Bodenschutz des Umweltbundesamtes, Flächenverbrauch einschränken – jetzt handeln. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/e6e82d01.pdf

[807] Luxembourg working paper on 'land take'

Member State	Land take definition	Policy	Target
SL	Net increase of the build-up area = area of built-up land in year n - area of built-up land in year n-1. Built-up land areas are areas on the earth's surface that include construction plots of buildings and construction engineering facilities with associated land[808]	National Spatial Planning Strategy 2050	

***Note**: the ha/day targets depicted in the table above are not directly comparable between Member States due the differences in populations and land mass sizes. The definitions highlighted here are not necessarily provided by the policy document indicated (sources given where applicable).*

7.2 LATA 1 – Definition of net land take

7.2.1 Description of option and requirements for implementation

LATA 1 involves establishing a definition of 'net land take'. The EU has limited competence on land take issues in Member States, therefore the focus of the analysis of LATA 1 is solely on the formulation of the definition itself. There is no binding target linked to LATA 1.

In order to achieve a better coordinated, comparable EU-wide dataset on land take, the definition would need to be specific and measurable. In addition, the definition could take into consideration natural land use changes to encompass the impacts of climate change on landscapes. The formulation of the definition could be two variants:

- LATA 1a- Under the first formulation, the Soil Health Law would introduce a **general, high-level EU definition** which would align with that provided by the European Environment Agency, whereby net land take is 'the mathematical difference between land take[809] and land recultivation. In other words, subtracting the area of recultivated land from the area of land taken gives a value for net land take.' However the use of the terminology 'recultivation' to describe the process of reclaiming land places land take solely in the domain of agriculture. As such, any use of such terminology should be clearly defined. This would include broadening the scope of land take to cover *all* land which has soil function/ is productive, and 'recultivation' should only refer to previously artificialized land.

- LATA 1b- Under the second formulation, the Soil Health Law would introduce a more-specific, but still EU-wide definition. Here, it would be necessary within the definition to define what constitutes 'artificial surfaces' and the opposite of 'land take', in order to enable the calculation of 'net land take'. To elaborate, practices which convert (land recycling/ recultivation) artificial areas to natural or semi-natural areas can counteract land take. The difference between land take and land recycling/recultivation constitutes 'net land take', however some artificial surfaces and land take processes can be temporary and/or not lead to loss of soil ecosystem services, could be excluded from net land take calculations. For this option a clear time span on the duration of artificial surface existence would be needed, in addition to clear definitions on which conversion practices are included within the scope of net land take calculations.

[808] Slovenian National Spatial Planning Strategy 2050 (in preparation- no information on potential targets)

[809] Defined as 'the increase in artificial areas over time and represents an increase in settlement areas (or artificial surfaces), usually at the expense of rural areas'. EEA (2019) Land take in Europe. Available at: https://www.eea.europa.eu/data-and-maps/indicators/land-take-3/assessment

A number of causes of land take exist, and are predominantly related to the following sectors and activities: population growth, housing (and cultural preferences of housing), services and recreation; industrial and commercial sites; transport networks and infrastructures; natural resource extraction; waste dumpsites; construction sites.[810] However, it could be logical for the definition of 'land take' to cover all productive soils (i.e. agricultural, forest and (semi) natural areas) in order to limit irreversible actions (particularly soil sealing) taking place on these priority soils.

Support was noted by some stakeholders for harmonising definitions around land-take and soil sealing in order to develop relevant, robust and comparable indicators. 61% (n=3549, the majority of which were non-EU citizens: 62%, n=672; followed by EU citizen: 18%, n=194; and 'other': 11%, n=119)) of respondents in the OPC indicated that soil sealing and land take were a 'very important' driver of soil degradation.

7.2.2 Assessment of impacts

The formulation of the definition would require the Commission and Member States to arrive at a common consensus, therefore costs can be expected for a consultation period. The definition would impact competent authorities responsible for the management of land/spatial planning, whereby they would be required to align any national/regional definitions on land take to those provided by the Commission following this consensus-building exercise. Competent authorities responsible for developing land/spatial planning would also benefit indirectly from policy synergies derived from applying a net land take definition across various policy domains. Furthermore, the Commission would be able to more clearly compare Member State progress towards net zero land take.

Economic

The only direct costs applicable to the development of this option is the effort required to formulate the definition itself. This will likely require low costs for the Commission to conduct consultations (including those as part of this Impact Assessment) and for stakeholders to participate in these consultations (i.e. the FTE costs to consult internally within organisations/institutions). These costs are estimated at a total one-off cost of €22,826[811] for the Commission and €242,640 for the EU-27 Member States. Further costs, borne by the Commission, may be required to develop guidance documentation to support the dissemination of the formulated definition (costs for guidance documents could be around €290,000 where this represents a simple guidance document).[812] Costs for LATA 1b are expected to be marginally higher than LATA 1a, due to the costs of comitology processes (further consultations with experts of Member States) to arrive at a commonly accepted definition.

Environmental

Limited environmental impacts are foreseen directly related to this option. Providing a definition is likely to improve the level and overall completeness of EU-wide data on land take. This could then have a subsequent, indirect on reducing net land take due to better comparison of data across the EU. The indirect environmental impacts of limiting

[810] EEA (2019) Land take in Europe. Available at: https://www.eea.europa.eu/data-and-maps/indicators/land-take-3/assessment
[811] Calculated as 'low' administrative costs
[812] From Tucker et al., (2013)- Estimation of the financing needs to implement Target 2 of the EU Biodiversity Strategy. Adjusted to 2022 value.

land take, which may be subsequently facilitated by developing a consistent definition of land take, include: climate impacts (if, for example net land take of productive soils and/or soil sealing trends are minimised), overall soil health improvements and related soil biodiversity, and potentially lower risk of flood events due to reduce water runoff from impermeable surfaces.

Social

Minimal social impacts can be expected, solely relating to the administrative requirements to apply the definition itself. Indirect benefits associated with the inter-generational preservation of soils and its related ecosystem services, particularly if soil sealing is minimised, can be expected to be substantial if actions to tackle land take are implemented following the development of the definition.

7.2.3 Distribution of effects

The only stakeholders directly impacted by the development of this option is the Commission through developing the definition itself and Member States who will need to adapt any national definitions on land take to align with the EU definition. LATA aims to facilitate a solution to the pressure of land take and soil sealing, which is predominantly an issue in urban and semi-urban areas. However, given this only places an obligation to define this threat, the direct impact on urban communities will be negligible.

7.2.4 Risks for implementation

The key risk for this option is the development of the definition itself, in particular whether a definition can be developed that is widely understandable and commonly applicable in all Member States. For LATA 1b, any specific details, such as the outlined potential inclusion of 'artificial surfaces', could potentially require more extensive consultations to refine the definition and implement through comitology.

7.2.5 Links /synergies

Certain forms of land take, namely soil sealing, can lead to complete/partial loss of soil ecosystem services, degrading overall soil health. This links to SHSD and MON as it could be reasonable to include (net) land take as part of a wider set of indicators defining good health for soils, and as a parameter that should be monitored if monitoring (LATA 2) is made compulsory. Furthermore, this option presents potential linkages to building block REM - as restoration measures could be directed towards previous land take actions.

There is also a critical link to the other option under this building block – LATA2. Without a common definition of what constitutes net land take, then the monitoring and reporting obligated under LATA2 could be undertaken on the basis of varying definitions across Member States, undermining the comparability of the data collected.

7.2.6 Summary assessment against indicators

Given the importance of land take impacts on soil health, formulating a common definition for EU usage would present a clear benefit in terms of furthering a common understanding of what constitutes good soil health, and to gather comparable data and information around the current state of soil health in the EU (linking to LATA2).

Furthermore, without this option, it will be challenging, if possible at all, to robustly track progress against the EU's 'no net land take by 2050' target. Although this option will not deliver any direct environmental and social benefits, it is an important facilitating measure for subsequent action around land take. There are synergistic linkages to other options (as mentioned in the above paragraph) as part of this impact assessment. Given that some Member States have already established quantitative targets within national policy to tackle land take, an EU-level definition would assist in refining approaches across the EU to ultimately ensure a level playing-field in assessing any progress towards 'no net land take' by 2050. A transition cost could be expected for those Member States who already monitor land take, though this would be related to the potential changes in monitoring procedures, relevant to LATA 2 and all other burden would fall on the EU.

Table 7-2: Overview of impacts

Effectiveness	**Impact on soil health**	(+)	No direct benefit, but important facilitating measure for any subsequent action on land take at national level.
	Information, data and common governance on soil health and management	+	Formulating a common definition for EU usage would present a clear benefit in terms of furthering a common understanding of what constitutes good soil health and facilitate comparable data gathering (overall benefit lower than other options as focuses on one soil threat)
	Transition to sustainable soil management and restoration	(+)	No direct benefit, but important facilitating measure for any subsequent action on land take at national level.
Efficiency	**Benefits**	+	Improvement in data and information key benefit
	Adjustment costs	**0**	No direct cost, but important facilitating measure for any subsequent action on land take at national level
	Administrative burden	-	Small upfront administrative burden (< EUR 1m)
	Distribution of costs and benefits	**0**	Upfront costs fall on EC
Coherence		+	Would positively complement option selected under SHSD
Implementation risks		-	Risk whether a definition can be developed that is widely understandable and commonly applicable in all Member States

7.3 LATA 2 – Obligation for Member States to monitor land take

7.3.1 Description of option and requirements for implementation

LATA 2 involves placing an obligation on Member States to monitor (and report on) progress towards achieving the EU target to reduce net land take by 2030 and to achieve no net land take by 2050.

The monitoring requirements would be an augmentation of MON, whereby (net) land take monitoring could be integrated into the EU Soil Observatory or the EEA's Land Information System for Europe - which would act as an oversight system. The monitoring system under this option, established by the EC, would oblige Member States to monitor (net) land take at a resolution sufficient to allow comparability amongst Member States, and report on this once every 4 years as a minimum (this acknowledges the frequency of land take changes, whilst allowing Member States sufficient time to collate and analyse data). LATA 2 would be dependent on, as a first step, the definition of 'land take', as per LATA 1.

Member States could use their own monitoring networks after updating and calibrating with the definition offered in LATA 1, or make use of EU level monitoring through

Copernicus. It is logical that the monitoring networks would use remote sensing and satellite imagery to analyse land take changes complemented with on-the-ground validation.

For Member States where monitoring networks related to land take are currently in place or are developed under this option, the INSPIRE Directive would apply. The INSPIRE Directive requires Member States to disclose their national data that must be collected on the basis of other environmental policy frameworks (at the EU-level, regulations related to land use include which data could be used include: the Habitats Directive, Environmental Impact Assessment Directive, Strategic Environmental Assessment Directive, Flood Directive and Water Framework Directive).

In response to the OPC, there was a strong agreement across all stakeholder types that there should be obligations for Member States to monitor and report on the progress towards the EU objective of "no net land take" by 2050 (although noting that the overall support for such an obligation was marginally less strong relative to other proposed obligations). 79% (n=4595) of all respondents 'totally agreed' this obligation should be put in place, with a further 13% 'somewhat agreeing'. Furthermore, 'totally agree' was the most common response across all stakeholder types. 67% (n=3901) of stakeholders thought it was 'very important' (the majority of which were EU citizens: 63%, n=2433) to include mandatory reporting by Member States on progress towards no net land take. Amongst public authority responses (the stakeholder impacted by such obligations), 52% (n=50) responded that mandatory reporting was 'very important', 22% (n=21) as 'important'. This support for monitoring and reporting was also emphasised in other engagement activities.

Responses to the OPC on particular aspects to be monitored relating to land take showed high support (i.e. responded 'totally agree') to all listed indicators: soil sealing (72%, n=977); land take (73%, n= 991); land recycling (56%, n=752) and land fragmentation (50%, n=671). In relation to the scope of potential monitoring procedures, stakeholders stated a greater preference for the monitoring of soils consumed for commercial activities/ logistics (69%, n=937 'totally agree') and airports, roads and carbon mines (70%, n=948 'totally agree') than soils consumed for renewable energies (55%, n=748 'totally agree', 25%, n=344 'somewhat agree').

7.3.2 Assessment of impacts

Economic

Estimating the ***administrative costs*** of monitoring is dependent on the definition of 'land take', and the scope which this covers. For Member States, the monitoring of land take would require the development of monitoring systems, including:

- Defining resources and funding required for monitoring land take, as per the prescribed required frequency and details included in the Soil Health Law;
- Establishing monitoring networks through the use of remote sensing/satellite imagery and surveying;
- Compiling information on (net) land take and artificial surfaces;
- Reporting procedures - whereby Member States are obliged to provide monitoring data and analysis thereof of (net) land take within the defined reporting period (i.e. every 4 years).

The costs of developing such systems is dependent on the current status of (net) land take monitoring and reporting in Member States. Those which currently have (net) land take monitoring systems in place can be expected to incur lower costs. The costs of this administrative burden are explored below.

Using the Nature Restoration Law Impact Assessment as an illustrative guide on requirements to administrative costs to establish national land take monitoring systems, an estimate of time inputs required is outlined below. The Nature Restoration Law requires Member States to, inter alia, develop national restoration plans- whereby a key component is assessing current extent and condition of ecosystems and establish resources required to monitor the condition of ecosystems. This covers all Habitats Directive surface area. Although it is assumed that the requirement to monitor land take would apply to all soils in the EU, thus a much greater surface area than the Habitats Directive, the monitoring approach (through remote sensing complemented by in-field surveys) would require fewer resources by Member States. As such, the estimated resources per action line presented in the Nature Restoration Law have not been altered. Member States which currently have targets to tackle land take are expected to have monitoring frameworks currently in place, and are therefore likely to encounter a lower administrative burden to fulfil the mandatory monitoring and reporting obligations.

Table 7-3: Estimated one-off resources required by each Member State to establish a land take monitoring framework

Requirement/ action	Time input (days), and type of cost
Compile and present data on net land take	600
Define monitoring and reporting arrangements	180
Establish reporting procedures	100

The resource estimates presented above are one-off administrative costs, to establish a baseline of land take in each Member State. This could be expected to take up to 2 years for Member States to develop. Applying a standard cost of approximately €217.40 per day to cover salary and overhead costs of public servants,[813] an average one-off cost of €190,960 would be incurred per Member State to establish land take baselines (i.e. 880 days or €5.17m across 27 Member States).

Further ongoing costs related to monitoring are expected, and the related reporting procedures. Consultations provided some cost estimates for monitoring by Member States.[814] The most sophisticated monitoring systems (i.e. those which monitor levels of artificialisation) are estimated at costing between €0.0091-€0.01 ha/yr, whereas less sophisticated versions (i.e. only monitor land take based on planning documentation and low-resolution satellite imagery) are calculated at approximately €0.003 ha/yr. Applying these average costs to Member States estimated as requiring low or high administrative burden to align current monitoring systems to those foreseen under LATA 2,[815] the EU-

[813] Taken from EC (2022) Applying the 'One-In-One-Out' scheme in DG Environment's impact assessments.
[814] Costs of monitoring artificialisation as part of the French 2021 Law on climate change and resilience- are estimated at €500,000 per annum; Czechia estimates that a brand new systems for monitoring would cost €80,000 per annum; the system in Austria which monitors land take through the use of multiple data sets is estimated at an annual cost of approximately €33,000 per annum.
[815] As stated in the baseline to LATA, all Member States are assumed to have some form of land take monitoring processes currently. Based on consultations and a review of documentation, the following Member States are estimated at requiring 'low' administrative burden to align with LATA 2, as they currently have specific LATA targets and/or evidence of detailed land take monitoring: AT, BE,

27 administrative burden per annum is calculated at €3,285,838- borne by Member States. In addition, ongoing, annual reporting costs (from the table above, assuming the 100 days for establishing reporting procedures would be similar for *ongoing* reporting requirements, and dividing this by 2 to give an annual estimate (reporting to occur every 4 years- above table is for a 2 year period)) are estimated at €10,869 per Member State (i.e. 50 days or €293,478 per annum across 27 Member States using the aforementioned standard cost of €217.40 per day).

Environmental

LATA 2 does not lead to any foreseen significant, direct environmental impacts.

However, indirectly, improved monitoring of land-take would support any subsequent measures which may be implemented to achieve no net land take, possibly prescribed through developed land take plans, the implementation of the land take hierarchy and target setting at Member State-level. These measures would then lead directly to positive impacts on soil health through preventing irreversible loss of ecosystem services due to land take, and positive impacts through the recycling of land and soils. Such ecosystem services are estimated at valuing €309/ha/yr.[816]

Social

The majority of social impacts would be borne by Member State Competent Authorities. For Member States without any (net) land take monitoring systems currently in place, they would be obliged to establish monitoring systems within their respective countries, or to utilise the current EEA or Copernicus data to develop national reporting. Member States would be likely to either upskill current staff monitoring environmental aspects using similar methods to those prescribed under the land take monitoring obligation (i.e. remote sensing/satellite imagery and in-field surveying), or employ new staff with the relevant skillset. For Member States with current land take monitoring systems in place, the administrative burden will be smaller. Broader societal impacts include enhanced knowledge on the state of land take (education and training, education, and training systems), technological development and innovation.

7.3.3 Distribution of effects

Those most impacted directly by LATA 2 would be the Member States themselves (development of monitoring frameworks, implementation of monitoring). Indirectly, as per LATA 1- at a later stage in implementation actors who are directly responsible for driving land take processes would ultimately be responsible for implementing actions to limit/reverse land take. LATA aims to facilitate a solution to the pressure of land take and soil sealing, which is predominantly an issue in urban and semi-urban areas. However, given this only places an obligation to monitor this threat, the direct impact on urban communities will be negligible.

DE, FR, LU, SK. The remaining MS are assumed to require 'high' administrative burden to align to LATA 2. High administrative burden is calculated as the average cost of establishing sophisticated monitoring from the data provided by France and Czechia in the above footnote- calculate at €0.009/ha/yr. Low administrative burden is calculated at €0.003/ha/yr from the data provided by AT.

[816] Figure from LIFE project Save Our Soil for LIFE (SOS4LIFE) relating to the costs of lost ecosystem functions provided by soils.

7.3.4 Risks for implementation

Implementation would require deployment of resources on behalf of Member State Competent Authorities to implement monitoring systems which are aligned at the EU-level. However, as outlined in the baseline, the Member States which currently monitor land use changes can be expected to incur lower costs (in consultations, Denmark and Germany noted that national-level monitoring of land take is implemented currently at sufficient resolution that no/limited administrative burden costs would be borne). Costs for such Member States can still be expected to transition to the EU approach. Other risks include the need for skilled resources for data management of monitoring networks, and any increase in monitoring risks a lack of such resources. In relation to the monitoring itself, the key risk will be how to assess 'net' land take- establishing clear parameters on the how land should be restored/recultivated in order to compensate for land take.[817]

7.3.5 Links /synergies

The option broadly links to building block MON- in particular MON 3, whereby soil monitoring and reporting is undertaken by Member States. If LATA 1 is to be considered as a parameter to be monitored by Member States, then it could be foreseen that the LATA 2 monitoring is integrated into a package of an EU-wide harmonised approach to monitoring soil health. LATA 2 could be inconsistent with MON 4, whereby all monitoring procedures are fully harmonised at EU level, in contrast to the flexibility given to Member States prescribed under LATA 2 (unless EEA/Copernicus data is used by the Member State in LATA 2). One potential way to synergise such approaches would be for the Commission to control a centralised database whereby Member States upload data.

7.3.6 Summary assessment against indicators

Establishing an obligation for all Member States to monitor and report (net) land take would present a clear benefit for improving the availability of comparable data and information around the current state of land take in the EU. Furthermore, without this option, it will be challenging to robustly track progress against the EU's 'no net land take by 2050' target. Although this option will not deliver any direct environmental and social benefits, it is an important facilitating measure for subsequent action around land take. The effectiveness of this option would critically hinge on LATA1 and the establishment of a common definition – without this there would be significant uncertainty around the comparability of the data collected. There is also an important link to MON, and perhaps aligns best with MON option 2 or 3 where monitoring requirements leave a certain degree of flexibility to Member States. Given that some Member States have already established procedures to monitor land take, an EU-level obligation would assist in refining approaches across the EU to ultimately ensure a level playing-field in assessing any progress towards 'no net land take'. A transition cost could be expected for those Member States who already monitor land take, though this would be related to the potential changes in monitoring procedures.

[817] Projects such as the 'DACHBoden' are currently being implemented between AT, DE and CH agencies to establish suitable compensation mechanisms for soil land used, but no clear frameworks/measures currently exist in the EU.

Table 7-4: Overview of impacts

Effectiveness	**Impact on soil health**	(+)	No direct benefit, but important facilitating measure for any subsequent action on land take at national level.
	Information, data and common governance on soil health and management	+	Establishing an obligation for all Member States to monitor and report (net) land take would also present a clear benefit for improving the availability of comparable data and information around the current state of soil health in the EU (overall benefit lower than other options as focuses on one soil threat)
	Transition to sustainable soil management and restoration	(+)	No direct benefit, but important facilitating measure for any subsequent action on land take at national level.
Efficiency	**Benefits**	+	Improvement in data and information key benefit
	Adjustment costs	0	No direct cost, but important facilitating measure for any subsequent action on land take at national level
	Administrative burden	--	Medium ongoing administrative burden (between EUR 1m to 5m pa)
	Distribution of costs and benefits	-	If Member States need to undertake additional testing to characterise the quality of restored land, this could lead to higher costs for some Member States
Coherence		+	Would positively complement option selected under MON
Implementation risks		0	No significant risks identified.

8 SOIL HEALTH CERTIFICATION (CERT)

8.1 Overview

8.1.1 Building block outline

This building block focuses on the establishment of certificates providing information on the health of soils, to inform land buyers to be aware of the health of the soils in the site they intend to purchase.

8.1.2 Problem(s) that the building block tackles

Soils in the EU are unhealthy and continue to degrade. This is partly driven by market failures around land transactions. Namely, buyers of land are not aware of soil health and cannot integrate restoration costs into land transactions, and – linked to this – land prices do not reflect externalities and cost of degradation. The introduction of Soil health certification would contribute to addressing these market failures by providing potential buyers with information about the soil health of the land they wish to purchase, thereby enabling them to negotiate a price that reflects the condition of the soil. This, in turn, is expected to incentivise landowners to maintain their soil in good health. In addition, certificates could be used as part of the transaction of land between landowner and tenant, allowing the landowner to track any degradation that occurs over the tenancy period.

Out of the 18 respondents from the Call for Evidence which addressed the issue of Soil Health Certificates, 12 supported the proposed approach.[818] From the 4 members of the Expert group who expressed an opinion, 3 supported this measure (although their

[818] Call for Evidence feedback

understanding of what it entailed differed),[819] and 1 was opposed, but only because they already have a similar system in place already (Finland).

8.1.3 Baseline

Although soil health is to some extent already regulated in certain Directives (e.g., the IED and the ELD, as discussed in annex 8, at EU level no policy exists on the provision of information on soil health when land changes ownership. The only Member States which are known to have a soil certification system for land transfer in place are Belgium (with slightly different systems in the Flanders, Wallonia and Brussels regions) and Finland. In these cases, the requirements placed on sellers for information provision relate to soil pollution, not soil health more widely. In Spain, the owner of a terrain is obliged to state under notary supervision if the terrain to be sold has supported a potentially soil polluting activity among those legally established in the same rule;[820] however, there is no obligation related to proving the claim (i.e., testing or providing a certificate issued by a public authority).

In Denmark, regional councils must register contaminated sites and register these sites, and owners of the site receive this information, which is also publicly available online. While it is common practice in real estate trading that agents present the document to the buyer of the specific property since the registration can affect the price and the use of the property, this is not a mandatory requirement.[821] In Germany, property buyers with a legitimate interest can obtain information from the register of contaminated sites, and in Austria it is common practice (although not mandatory) that the seller provides information on the soil condition of the site. Finally, in the Netherlands, regulation states that all soil related information known by the seller must be available for the (potential) buyer, but no certification is in place and the buyer remains ultimately responsible for soil-quality, pollution and any obligatory remediation once the purchase is made.[822]

Without EU intervention, it is expected that the situation will not significantly change in the foreseeable future (i.e., that no or few other Member States will introduce Soil Health certificates or equivalent unilaterally).

8.2 CERT – 1 – Certificate bearing on the contamination status of plot of land

8.2.1 Description of option and requirements for implementation

CERT 1 focuses on the establishment of certificates providing information on the contamination status of soils on properties, in order for land buyers to be aware of potential issues in the site they intend to purchase.

Under the CERT 1, the EU would define the Soil Health Certificate as: (1) delivered by public authorities in each Member State; (2) based on the values recorded on the plot of land for the descriptors for soil contamination; (3) provided on a voluntary basis at the time of the sale of land, and for all properties in the EU, except on private urban properties where no contamination is suspected (based on the identification of potentially

[819] Belgium, Portugal, Spain
[820] Spanish Legislation on contaminated soils (RD09/2005)
[821] Targeted consultation with MS
[822] Targeted consultation with MS

contaminated sites undertaken as part of the DEF building block) – these sites are proposed to be excluded to ensure costs are proportionate, furthermore all contaminated sites will be identified as part of the DEF building block.

Member States would be given the autonomy to decide, based on EU mandatory guidelines, the several elements of the Soil Health Certificate design. This includes: the list of soil descriptors included and conditions for Certificate to be issued based on the thresholds or ranges of values for non-contaminated soil (to be determined at Member States or EU level, depending on the DEF Option chosen), time range within which testing must be done before the sale (e.g. within three months before land is sold). The certification would provide a 'score' based on the overall contamination status of the soil - with a low score indicating general 'a high level of contamination' and a high score 'a low level of contamination'. Member States would be able to add their own standards for validity to meet their specific Member State needs (beyond the requirement that the Soil Health Certificate should be provided for property sales to occur). For instance, in Finland, Flanders and the Brussels Capital Region the certificate must be provided when land is being sold, but also when it is being rented to a new tenant.

Under CERT 1, sellers who decide to provide a Soil Health Certificate to buyers would need to provide this document to the notary, who would register it in the file attached to the piece of land. The obtention of this document would be at the expense of the seller. While the measure is voluntary, if the seller does not wish to provide a Soil Health Certificate, the plot of land sold will automatically receive the lowest score available.

Under the DEF building block, Member States would be obliged to identify all 'potentially contaminated sites' and to publish this list in a public register. In addition, Member States would be obliged to identify all 'contaminated sites' and all 'sites requiring remediation', and to publish these lists in a public register. Under CERT 1, if no data on the contamination of a site is yet recorded in the system (i.e., before all sites are identified under DEF) or if this data is potentially outdated, soil testing from an accredited laboratory should be undertaken to assess whether the site is contaminated (i.e., a soil investigation). The results would have to be sent to the relevant public authorities.

More than three quarter of OPC respondents (n=4411; 76%) who replied to a question on whether there should be legal obligations for Member States to set mechanism informing the buyer about the health of the soil when land is sold "totally agreed" with this measure, and a further 17% (n=988) "somewhat agreed", highlighting a strong support for this measure. Moreover, 58% (n=3105) preferred this measure to be implemented via an official and mandatory "certificate" on soil health. Finally, 62% (n=3593) stated that this measure is "very important" to achieve healthy soils in the EU by 2050. These results highlight that a majority of OPC respondents highly supported this measure and believed it would be an effective instrument to achieve healthy soils.

8.2.2 Assessment of impacts

Economic

The major costs expected under this option would be borne by the European Commission, national authorities and property owners. In particular, there would be an ***administrative burden*** for both the European Commission and Member State public authorities to implement the option.

The European Commission would bear some administrative costs associated with the time needed to set up guidelines and provide guidance to Member States with regards to topics such as: how to set-up an online registry, how should the form look like, how to easily present information to landowners and prospective buyers (e.g., one option could be a colour-of-letter based system like the ones used for energy labels). In addition, the European Commission would need to allocate resources to replying to Member State queries while they set-up these systems. The costs of developing the required guidelines/guidance are expected to be €290,000 (i.e. a 'simple' guidance document).[823]

Member State public authorities would incur several costs, including expenses related to: designing and developing the policy framework (content of certificate, format, etc.); setting up and managing a database containing information needed for the Certificate to function (IT development, logistics to log all data onto the platform, ongoing maintenance costs); and reporting costs (to the EC). The online platform that issues the certificates would be linked to the registry of contaminated sites to be developed under the DEF building block. EU guidance on how to best set-up the platform based on best practice would help to ensure that costs are minimised while helping to achieve a degree of harmonisation across Member States.

The implementation of similar systems in the three regions of Belgium are useful examples to understand the costs but also the financial returns that this measure could entail. Wallonia has provided the most detailed cost data. A total of 5.06 million euros was spent during 2011-2022 for the set-up and maintenance of the soil database,[824] which contains publicly-available data on the state of soils in Wallonia and is used to request soil certificates (for a price breakdown, see **Error! Reference source not found.**). Certificates are delivered automatically; however, if a risk of contamination exist, they must be complemented by a Certificate of Soil Control (i.e., an investigation on soil contamination). About 200,000 certificates were delivered annually since 2019 and applicants are charged a fee of about 30 euros each to receive the certificate. As a result the region is recovering about 6 million euros annually and hence the system more than covered its operating costs by 2022.

[823] Based on a study by Tucker et al., 2013, which estimated that the cost of developing guidance documentation with existing knowledge (in this example, guidance on the management of farmland in Natura 2000 areas) was approximately €290,000 (in EUR 2022, adjusted to account for inflation). Source: Tucker et al., 2013, Estimation of the financing needs to implement Target 2 of the EU Biodiversity Strategy.
Available at: https://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/Fin%20Target%202.pdf
[824] "Banque de Données de l'Etat des Sols –BDES" - http://bdes.wallonie.be/

Table 8-1: Administrative burden breakdown of the set-up and running of the Soil Health Law Certification system in Wallonia, in thousands of euros[825]

Phase	Costs (000's EUR)	Description
Phase 1: Set up of the online platform (2011-2015)	1,500	IT developments (including the structuration of data from soil experts)
	500	GIS work
	1,200	Search of historical activities based on historical documents
	1,200	Extracting information from local authorities
Total phase 1	4,400	
Phase 2: Set up delivery of certificates (2016-2018)	500	Set up delivery of the certificates (called "Extrait conforme de la BDES")
Total phase 2	500	
Phase 3: ongoing running of the system (2019-ongoing)	40 (annual costs)	Maintenance of BDES costs, including team of 2 IT specialists
Total phase 3	160	Costs 2019-2022
TOTAL 2011-2022	**5,060**	

In Flanders, where the obtention of a Soil Certificate is mandatory when land is transferred (transfer of ownership, but also ground lease, usufruct,[826] concessions, etc.), 322,000 certificates were requested in 2021 alone, each for a price of €55 paid from the seller to the public administration. This means that, for that year, public authorities retrieved €17.71 million that can contribute to the administrative costs required for the functioning of the soil certification system. However, no data on the costs for the administration was provided.

In the Brussels capital region, a web platform (Brusoil) has been set up where experts input technical data, which is then imported into the internal database, using 'web services' technology. The database then automatically generates certificates. About 90% of cases are automated, and the remainder are processed manually as they require an analysis. Initial investments for the IT tools totalled around €500,000, and they are upgraded every year at a cost of €100,000/year. Moreover, a team of 4 IT specialists work on the tools.[827] There, requesting a soil certificate costs €39, but no data was found on the number of certificates sold.

These examples show that while the costs of setting up the database can vary, public authorities can retrieve significant revenues by requiring those needing the certificate to pay for it. In addition, if MS collaborate in the set-up of their platforms (e.g. by relying on similar designs), costs could be lower overall. Using the examples of Wallonia and Brussels Capital Region, an illustrative estimate of the additional costs of implementing this measure across all remaining 25 EU Member States (i.e., minus Belgium and Finland) is presented in the Table below. The capital costs stem from the Wallonia example, and the costs associated with information gathering are not included here as

825 MS response from Belgium
826 Defined as the right to use, enjoy, or earn income from a property that belongs to someone else, without destroying it or degrading its value.
827 MS response from Belgium

these are part of the DEF building block. The running and maintenance costs (upgrade of IT tools and 4 IT specialists) are taken from the Brussels example as the set-up of the system (some of the case not being automated) matches more closely how the implementation of CERT 1 is foreseen.

Table 8-2: Overview of expected administrative burden to be borne by national public authorities, in thousands of euros.

Item	Cost to each national authority (000's EUR)	Costs to national authorities (total for 25 Member States, 000's EUR)
Set up of the online platform and the delivery of certificates (one-off)	2,000	50,000
Running and maintenance costs (annual)	300	7,500

Costs could be borne by owners of properties who wish to sell it and to provide the buyer with a certificate, depending on the structure of the policy in each Member State. These could stem from: (1) a fee for the request for a certificate to be filed, which may hover around €30-40, as per the case of Belgium; and (2) to get soil testing results to be performed by an accredited laboratory. The costs of soil testing are already included under the DEF building block, i.e. EUR 24,000 per testing (in practice, this amount would be higher for larger (commercial) sites, but lower for residential properties). CERT 1 would bring some of these costs forward in time, in cases where properties at risk of contamination without data yet change ownership. As these costs are already covered in the DEF building block, here is only included a reflection on the number of testing that may be undertaken under CERT 1 rather than under DEF.

The number of tests for contamination would decrease until reaching zero by 2035 (i.e., assuming that, by then, the DEF building block would be fully implemented and hence all contaminated sites identified). An overview of the number of tests conducted under CERT 1 per year is presented in the table below.

Table 8-3: Estimated number of tests undertaken under CERT 1, 2024-2034

Year	Number of tests at EU-27 level[828]
2024	115,584
2025	105,952
2026	96,320
2027	86,688
2028	77,056
2029	67,424
2030	57,792

[828] Calculated based on the Wallonia and Flanders examples on the number of certificates issued per year, scaling up the certification/population to EU27 and dividing the total by two to account for a lower number of certification issued due to the voluntary nature of the measure (whereas certificates are mandatory in Belgium). From this total, 1% of properties is assumed that would need to undertake testing for contamination (where there is a risk of contamination).

2031	48,160
2032	38,528
2033	28,896
2034	19,264
2035	231

The administrative burden on businesses is not expected to be significant as filing for a certificate online is quite straightforward. In cases for which additional testing is required (i.e., when the registry has no data or outdated data on the plot of land), the public authorities could provide the landowner with a list of accredited laboratories that can come to undertake the measurement, in order to facilitate the process for businesses.

Following the cost estimates presented above, an overview of the costs of CERT 1 is presented in the table below. It is important to note again that the amount paid by sellers of properties to buy certificates will be transferred to national public authorities, enabling them to compensate the costs of creating and maintaining the online platform, and potentially as well to fund remediation activities.

Beyond this, indirect impacts can be expected to affect individuals, public authorities and businesses (and ***SMEs***) selling land, whereby the impacts of an indicated poor soil health could have detrimental impacts on land/property value. Complying with the measure is expected to put the seller at a competitive advantage compared with those which do not provide the information (see evidence for EPCs in

Textbox **1**).

Table 8-4: Synthesis of main costs for CERT 1, per stakeholder type

Stakeholder bearing the cost	Item	Cost at EU27 level
European Commission	Guidance document	EUR 290,000 (one-off)
Member States	Costs to establish certification platforms in MS	EUR 50,000,000 (one-off)[829]
	Ongoing maintenance costs of the platform	EUR 7,500,000 (annual)[830]
Sellers of properties	Purchase of certificates	EUR 477,760,000 (annual)[831]
	Soil testing for contamination	Already covered under the DEF building block

No negative ***impacts on competitiveness*** within or outside of the EU are expected, as people seeking to purchase properties often compare prices within a restricted region (sub-national or national level), and as the impact of this measure on the overall price of properties is expected to be minimal.

[829] EUR 2 million * 25 EU MS with no such platform in place
[830] Maintenance of the IT tool (EUR 100,00) and 4 IT specialists (each EUR 50,000) for 25 EU MS
[831] Calculated based on the Wallonia and Flanders examples on the number of certificates issued per year, scaling up the certification/population to EU27 and dividing the total by two to account for a lower number of certification issued due to the voluntary nature of the measure (whereas certificates are mandatory in Belgium). The price of one certificate was calculated using the average price of certificates in the three regions of Belgium (EUR 41.3)

If landowners decide to comply with the measure, they may however wish to undertake activities to improve the contamination status of their land, which would carry costs. These costs would overlap somewhat with those already accounted for in the REM building block, where the costs of remediating contaminated land generally are captured. In Flanders, one public authority noted that the Certificate had a strong awareness impact on the behaviour of landowners.[832]

The costs to be borne by the European Commission and by national public authorities are fixed, whereas the costs to be borne by property owners depend on whether they wish to comply with the Soil Health Certificate. This, in turn, can depend on a variety of factors, including demand from buyers (and how informed they are regarding the scheme), perceived ease of complying, impacts of obtaining a Certificate on the market price of the property, etc.

Environmental

Evidence on the potential effectiveness of Soil Health Certificates in terms of impact on soil pollution prevention and soil remediation remains limited. If effectively set up and enforced by Member States, and if voluntary compliance is significant (meaning that the effectiveness of this option depends on the behavioural response of landowners), this Option could contribute positively to the remediation of contaminated sites, therefore positively impacting ***soil quality*** and **biodiversity**. It is however noteworthy that effectiveness may be limited in cases where land does not often change ownership, or conversely, changes in land ownership could spur action on remediation sooner than actions foreseen under REM, as a direct incentive (placed on the land owner) is in place for CERT. Moreover, ultimately the benefits linked to remediation overlap with those under REM, although the expectation is that CERT could contribute to bringing about some remediation action sooner than under REM.

In order to ensure the uptake of the measure and – by doing so – enhance its environmental benefits as well as the revenues derived from the scheme, Member States may choose to make the obtention of a Soil Health Certificate mandatory. Under a mandatory scheme – and as is the case in Flanders – if soil contamination is detected for which further action is required, the transfer of the land would not be authorised to take place before the following conditions are met:

- a soil remediation project has to be prepared;
- a financial guarantee has been deposited;
- a contract that the remediation will be carried out has been signed.

In Belgium, more than 1,600 sites contaminated with Mercury were identified as a result of its stringent contamination laws which mandate soil investigation for all potentially polluting risk activities before the land can be sold. By comparison, other Member States claim to have no sites contaminated with Mercury. Reporting this example, the SWD of the Soil Strategy[833] states that there is no reason to believe that Belgium is "dirtier", which suggests that contamination is underreported – rather than inexistent – in other countries, and at the same time highlights the role of the soil certification system in identifying contaminated sites. Here – as aforementioned - CERT 1 could complement

[832] Targeted consultation with MS
[833] EU Soil Strategy to 2030

DEF (which mandates that Member States identify all 'contaminated sites' and all 'sites requiring remediation' by 2035) by speeding up this process via the Soil Certificate.

Experiences and lessons learnt from the implementation of Energy Performance Certificates (EPC) can offer some insights on the potential effects of such a voluntary system, bearing in mind the limitations of such a comparison (see

Textbox **1**). The evidence found suggests that EPCs can be effective tools, ultimately leading to positive environmental impacts, but that the design of the system and its implementation by Member States are important influencing factors.

Textbox 1 Evidence from the implementation of Energy Performance Certificates (EPC)

EPCs were first introduced by the Energy Performance of Buildings Directive (EPBD) in 2002 (2002/91/EC) in order to make the energy performance of individual buildings more transparent, and the system was updated in subsequent EU legislation. A survey-based study in 12 EU countries found that, although results varied per country and age group, on average, EPCs played a role both in renovation decisions and whether to rent/buy a certain flat. This role remained nevertheless limited because of the limited uptake of EPCs (enforcement issues), lack of awareness of their existence, and lack of understanding of the meaning of the ratings.[834] Reaching similar conclusions, another study argued that "different implementation approaches (by Member States) have led to a diverse set of instruments, varying in terms of scope and available information, resulting in some cases in limited reliability, compliance, market penetration and acceptance."[835] Another study relying on a large sample of family homes in the Netherlands (> 870,000) found that energy-rated homes sell faster than non-energy-rated homes. Furthermore it highlighted that this effect varied by 7–12% depending on model specifications and increases when positive (green) ratings are granted,[836] highlighting that obtaining the label and obtaining a high rating increase the competitive advantage of a property.

Social

The identification of contaminated sites, even without remediation, is expected to positively impact ***public health and safety*** because activities on the land will be influenced by the knowledge of its contamination status (e.g., no urban gardens on contaminated sites). The EPC example (

Textbox **1**) however highlights that certificates must be designed in a way that makes them easily understandable to the general population. A Belgium public authority also stressed the importance of designing the certificate in such a way that its contents is clear (simplification and synthesis of information, associated consequences, etc.) so that users can understand it easily and that the soil certificate can serve as a good communication tool for soil awareness raising.[837] If the identification of the sites through certification

[834] https://www.researchgate.net/publication/323638392_The_impact_of_Energy_Performance_Certificates_on_building_deep_energy_renovation_targets

[835] https://www.bpie.eu/publication/energy-performance-certificates-in-europe-assessing-their-status-and-potential/

[836] https://www.sciencedirect.com/science/article/abs/pii/S0095069618305084

[837] MS response from Belgium

leads to remediation action, there would be additional indirect benefits for public health and safety would increase as the potential cause of harm would be reduced or removed entirely.

This measure is expected to have a small, direct positive effect on ***employment*** associated with: the IT services needed to set up and maintain the repositories in all EU Member States (as seen in the Belgium examples), as well as additional services in testing laboratories and businesses specialised in remediation of contaminated sites, as an increasing number of people will request their services. These latter effects are however dependent on the uptake of the measure. No negative effects on employment in other sectors are foreseen.

As for the environmental impacts, the social impacts depend on the voluntary uptake of this measure by landowners, i.e., their behavioural response to the measure and the influence that the Soil Health Certificate has on the price of properties.

8.2.3 Distribution of effects

Under this Option, the EC and Member State public authorities would be required to invest some financial and time resources into the set-up of a functioning Soil Certificate system in the short-term, including the registry. Efforts are expected to be less significant in Member States which keep relatively up-to-date registries of contaminated sites. Geographically, this measure will have a greater positive effect on regions with a higher number of legacy contaminated sites (i.e. in regions where industrial activities have been performed over a long period of time with limited / no regulation on soil pollution) because it will contribute to their identification and potentially remediation of a greater number of sites in these areas.

On the compliance side, the stakeholders expected to be most affected are landowners who wish to sell their properties (except those selling residential properties where the option would not apply). Costs may be higher for owners of larger properties where contamination is a risk (or where information is not already included in the reference database) and additional testing needed, as more samples would need to be tested. The voluntary nature of the measure means that these stakeholders may choose not to obtain a certificate, but this decision may place them at a competitive disadvantage against other sellers who have obtained a certificate.

Geographically, this measure will have a greater effect on regions with a higher number of legacy contaminated sites.

8.2.4 Risks for implementation

The following risks have been identified:

- Competent Authorities have insufficient expertise / resources to set up a well-functioning certification system in their jurisdiction, leading to delays or ineffective systems (e.g. long waiting times to obtain certificates, lack of information on the processes to follow when someone seeks to sell a property, etc.)
- The voluntary nature of the system may affect its uptake, with only a small proportion of landowners (for whom soil contamination is not an issue)

complying with the measure (e.g., because prospective buyers are unaware of the importance of soil health on the property they are purchasing)

- In cases where landowners know the soil is contaminated, they would be unwilling to obtain a certificate (i.e., to have that assessment made official and having to pay for this). In such cases landowners may just decide not to obtain a certificate and tell prospective buyers that the test was not undertaken and give a plausible explanation as to why this was not the case.
- Not enough laboratories able to get an accreditation to perform the tests, leading to high costs / backlogs.
- Inconsistency in the design of Certificate across Member States, in particular where the thresholds chosen to determine contamination status vary
- Question on liability if the measure will be introduced now, but the current owner of the parcel was not the one who polluted it (and was possibly unaware that it was polluted at the time of purchase). In Flanders, a subsidy system for soil remediation exists and is partly funded by the profits made by the Soil Certification system implemented. A similar system could be set up by Member States, via which the current landowners who are found not to be the ones responsible for the pollution of the site could receive subsidies to remediate the site. This solution could partly solve the issue of liability, although in instances when soil remediation is very expensive public authorities may be unwilling or unable to offset the costs fully.

8.2.5 Links /synergies

CERT 1 is strongly linked to all Options of Definition (DEF), which focus on the identification of potentially contaminated site and of those requiring remediation, by contributing to the identification of these sites. The identification of the sites as part of DEF will also feed in the registry set up under CERT 1. CERT 1 is also strongly linked to the Options under Remediation (REM). The Soil Health Certificate is a ‘soft’ incentive measure for owners of potentially contaminated soils to engage into remediation, which could nonetheless be set up by Member States alongside more coercive obligations and deadlines at national or EU level. The added value of CERT 1 would only be to contribute to preventing contamination once all potentially contaminated sites are remediated.

8.2.6 Summary assessment against indicators

This Option is expected to have a small indirect impact on soil health if landowners remediate land in order to obtain a certificate showing it is non contaminated, dependent upon uptake of the voluntary measure, itself dependent on the benefits (positive impacts on land value) vs costs of the measure for landowners. A small positive effect on information is expected as this measure seeks to increase awareness on soil contamination and will contribute to gather granular data on contaminated sites, as well as a small indirect positive impact on the transition to sustainable soil management and restoration, for the same reason as justification given on “impact on soil health”. The measure is foreseen to have a moderate negative impact on adjustment costs due to the costs of testing to be borne by landowners and the admin costs to be borne by the EC. These adjustment costs will however be concentrated on the owners of contaminated sites, and hence have a distributional effect. It is also important to note that if DEF is implemented, all costs related to testing would already be covered under that building block. However, national public authorities can compensate their costs by making people pay for the issuance of Certificates. A small negative impact is also foreseen on admin burden as some time would be required at EU and Member States level to set up and run the Certificate system. A small positive effect on distribution of costs and benefits is expected as this measure will influence the price of a property based on soil contamination, ensuring the polluter is financially penalised and does not pass on the contaminated soil to an unaware buyer. The measure is coherent with DEF and REM. Finally, a small negative implementation risk exists as the burden of legacy issues is placed on the current owner, in addition to other implementation risks aforementioned.

Table 8-5: Overview of impacts

Effectiveness	**Impact on soil health**	(+)	Indirect benefit where landowners remediate land in order to obtain a certificate showing it is non contaminated.
	Information, data and common governance on soil health and management	+	Option will increase awareness of soil health in land owners and prospective buyers as this information becomes a visible part of the process and documentation around land transactions, hence improving data and information available. Potential benefit lower than other options due to implementation risks.
	Transition to sustainable soil management and restoration	(+)	Indirect benefit where landowners remediate land in order to obtain a certificate showing it is non contaminated
Efficiency	**Benefits**	+	Improvement of data and information is key benefit.
	Adjustment costs*	**0**	No direct adjustment costs
	Administrative burden	---	Option implies large (> EUR 5m pa) ongoing administrative cost for Member States to manage and maintain system to issue certificates (but cots can be recouped through a certificate charge, and assumes all Member States implement individual, separate systems. Costs significantly lower than CERT2)
	Distribution of costs and benefits	+	Small positive effect as certificate will influence property value, better reflecting the polluter pays principle
Coherence		+	Remediation of all sites already mandated under REM, so benefits (and costs) overlap. But could complement REM in that some remediation activities are brought forward. Relies on information gathered under DEF to ensure administrative burdens remain limited.
Implementation risks		-	Several risks limit potential achievable benefits: uptake is voluntary; only impacts where land is sold; and implicitly places burden on current land owner.

Note: in this case, assessment of adjustment costs assumes implementation of an option under DEF, which is deemed a likely scenario, hence additional costs of CERT1 are anticipated to be small. Where DEF is not implemented, adjustment costs of this measure would be moderate.

8.3 CERT – 2 – Certificate bearing on the Soil Health status of plot of land

8.3.1 Description of option and requirements for implementation

This building block focuses on the establishment of certificates providing information on the overall health of soils on properties, in order for land buyers to be aware of the health of the soils at the site they intend to purchase.

CERT 2 differs from CERT 1 regarding two major aspects: the soil characteristics that the Certificate covers (soil health generally rather than contamination specifically) and its scope (under this option, the focus is solely on forestry and agricultural land, also including urban land where food is grown).

Under this option, CERT 1 would still apply to the properties within its scope which are not covered under CERT 2 (i.e., all properties, except agricultural land, forest land and private urban properties where no contamination is expected). For those properties, a certificate system as introduced under CERT 1 would need to be set-up also under CERT 2, and for agricultural and forest land a broader certificate system would be needed.

Under CERT 2, the EU would define the Soil Health Certificate as: (1) delivered by public authorities in each Member State; (2) based on the values recorded on the plot of land for the descriptors for minimum soil health and on the threshold or range of values for each descriptor to rate soil health status as being 'good' for each soil type, climatic condition and land use (as defined under SHSD); (3) provided on a voluntary basis at the time of the sale of land, and for certain types of properties only (where a soil polluting activity has taken place, on agricultural land and on forest land). This option focuses on these land types as they are the ones for soil health (beyond soil contamination indicators) has the most impact on the value of land.

Member States would be given the autonomy to decide, based on EU mandatory guidelines, the content of Soil Health Certificate, that is: list of soil descriptors, conditions for Certificate to be issued based on the thresholds or ranges of values for 'good' soil health, time range within which testing must be done before the sale (e.g. within three months before land is sold). Again based on EU guidelines, Member States would be able to add their own standards for validity to meet Member State needs (beyond the requirement that the Soil Health Certificate should be provided for property sales to occur). For instance, in Finland and in Flanders the certificate must be provided when land is being sold, but also when it is being rented to a new tenant (noting that in these two cases, the scope of the certificate is only on contamination, not soil health more generally speaking).

Under this Option, sellers who decide to provide a Soil Health Certificate to buyers would need to provide this document to the notary, who would register it in the file attached to the piece of land. The obtention of this document would be at the expense of the seller. While the measure is voluntary, if the seller does not wish to provide a Soil Health Certificate, the plot of land sold will automatically receive the lowest score available (i.e. ‘poor’ health of soils).

The MON building block implies the set-up of a database containing data on soil health by national authorities. Under CERT 2 this data would have to be linked with a platform that can deliver Soil Health Certificates. However, it is highly unlikely that the information collected under MON by national authorities would be available to such a level of granularity that it would be specific to any parcel of land subject to a transaction. As such, in addition sellers who decide to comply with the measure would need to get the soil on their land tested by an accredited laboratory to assess whether the health of the soil on the site (i.e., a soil investigation). The results would have to be sent to the relevant public authorities.

There is no known example of Member States or region having introduced Soil Health Certificates that focus on soil health in the broad sense of the term (i.e., also focusing on aspects such as soil organic carbon, pH, etc.), rather than only on pollution/contamination. Without EU intervention, it is not expected that EU Member States will set up such Certificates in the foreseeable future.

8.3.2 Assessment of impacts

Economic

The costs foreseen under CERT 1 would also be required under CERT 2, i.e.: the ***administrative burdens*** borne by the European Commission and by national public authorities to set up processes and systems to issue certificates related to contamination and to soil health, and costs to landowners to purchase certificates (where they are charged to do so) and get additional sampling performed by accredited laboratories, if it is required in their specific case.

Under CERT 2, additional costs. Monitoring of soil health will be undertaken as part of the MON building block, based on the delineation of soil districts established as part of SHSD. In cases where soil testing in these districts has been undertaken on the plot of land to be sold (within a timeframe to be defined), the landowner would not have to undertake additional sampling, which would reduce costs (they would only need to pay to obtain a certificate, but not for the sampling to take place). However, it is expected that sampling would still need to occur in most cases to obtain a certificate valid for the piece of land subject to the transaction, assuming that the granularity of sampling undertaken following the MON and SHSD building blocks will not be at the level of individual properties. As such, additional costs of soil testing would be borne by owners of agriculture and forest land to gather information on the health of the soils on a specific area of land subject to the transaction (because the laboratories would test for more parameters and because the plots of land are likely to be larger on average). An overview of the costs expected under CERT 2 is presented in the Table below.

Table 8-6: Synthesis of main costs for CERT 2, per stakeholder type

Stakeholder bearing the cost	Item	Cost at EU27 level
European Commission	Guidance document	EUR 290,000 (one-off)
Member States	Costs to establish certification platforms in MS	EUR 50,000,000 (one-off)[838]
	Ongoing maintenance costs of the platform	EUR 7,500,000 (annual)[839]
Sellers of properties	Purchase of certificates	EUR 477,760,000 (annual)[840]
	Soil testing for soil health (agricultural land)	EUR 21.6 million (annual)[841]
	Soil testing for soil health (forested land)	EUR 11.5 million (annual)[842]
	Soil testing for soil	Already covered under the

[838] EUR 2 million * 25 EU MS with no such platform in place

[839] Maintenance of the IT tool (EUR 100,00) and 4 IT specialists (each EUR 50,000) for 25 EU MS

[840] Calculated based on the Wallonia and Flanders examples on the number of certificates issued per year, scaling up the certification/population to EU27 and dividing the total by two to account for a lower number of certification issued due to the voluntary nature of the measure (whereas certificates are mandatory in Belgium). The price of one certificate was calculated using the average price of certificates in the three regions of Belgium (EUR 41.3)

[841] According to Eurostat data, the number of farms that can be estimated to be engaged in commercial activity can be estimated as those whose yearly economic output is above EUR 25,000. There are such 1.8 M farms in the EU in 2020. In order to estimate the number of transactions (change of property or of tenant per year), which would be susceptible to apply for a Soil Health Certificate, an average duration of exploitation of 45 years can be assumed, after which the current owner or tenant changes to the next generation. This leads to 40,000 changes of property or of tenant per year in the EU, for farms involved in commercial activity. Of this number, could be assumed that ca. 50% will elect to create a Soil Health Certificate, leading to a total number of certificates in the range of 20,000 certificates / year in the EU.

[842] According to data compiled by EFI, there are 1.6 million of forest owners of more than 10ha in the EU, and 60% of forest is privately owned (ca. 960,000 parcels). Based on a rotation of property of 45 years and assuming that 50% will opt for a certificate, a total number of certificates of 10,667 certificates per year in the EU is expected.

	contamination (other land)	DEF building block

Hence given the voluntary nature of the option, the additional costs of testing may be prohibitively expensive in many land transactions, which could severely curtail uptake. This may be particularly the case for agricultural land given undertaking testing and obtaining a certificate may not be the only nor the most cost effective option to communicate information regarding soil health before purchasing a plot - other information (e.g., historic yields) could be obtained or a visit of the field by the buyer (e.g., to observe compaction and soil depth) could be undertaken as part of typical due diligence already undertaken around such land transactions. This point was reiterated by stakeholders, who noted that farmers that practice sustainable agriculture are already rewarded by the market for higher prices for their land and/or a greater willingness to rent land from them.

Where CERT 2 triggers a behavioural response from landowners, who decide to improve soil quality on their land so that this is reflected in the Certificate, the types of activities to be undertaken would have different costs than those undertaken under CERT 1, as their scope would be different (improving soil health rather than reducing contamination). The ***adjustment costs*** of the measures to be undertaken would greatly vary, for instance based on the type of soil health issue, the degree of degradation, the physical properties of the parcel of land, etc. Furthermore, links to REST are present here- as CERT places the obligation/incentive directly on land owners to implement actions to restore soil health. Given the granularity of testing occurring under CERT, it could be foreseen that restoration actions have a greater additional impact above REST- acknowledging this is dependent on the uptake of the voluntary measure.

As under CERT 1, no negative ***impacts on competitiveness*** within or outside of the EU are expected, and the costs to be borne by the European Commission and by national public authorities are fixed, whereas the costs to be borne by property owners depend on whether they wish to comply with the Soil Health Certificate. This, in turn, can depend on a variety of factors, including demand from buyers, perceived ease of complying, impacts of obtaining a Certificate on the market price of the property, etc.

Environmental

This Option is expected to capture the same environmental impacts as CERT 1 with regards to contaminated soil. In addition, it could have a positive impacts on ***soil health*** more broadly, on agricultural and forest land, where land owners take up the certificate and improve or restore land in response. One expert from Belgium argued that an extension of the certificate for contaminated sites used in Brussels to include considerations related to soil health, as envisioned in this measure, could be an important lever for testing the soils and getting the required remediation, and that this measure could also be useful in keeping buyers informed on actions required if they buy land.[843] These effects of the Certificate would have environmental benefits, by improving or maintaining soil health. However, effectiveness would be limited in cases where land does not often change ownership. For instance, one public authority respondent from Ireland stated that transfer of ownership for agricultural land is not commonplace in the country,[844] which may also be the case in other EU countries.

[843] 1st Meeting of the EU Expert Group on the Implementation of the EU Soil Strategy. October 4th, 2022
[844] MS response from Ireland

Overall, it is expected that other measures, notably under SSM, would have greater and more direct impacts on soil health.

Social

The indirect impacts on ***public health and safety*** captured under CERT 1 would also be captured here (i.e., activities on the land will be influenced by the knowledge of its soil health status). Additional positive impact on health could stem from an increase in food quality, if the measure succeeds in incentivizing farmers to have soils of better quality, and as awareness on soil quality of their land increases. The latter however would be limited by the number of land owners taking up the voluntary scheme, and the level of overall land transactions over the period, both of which could be low.

Regarding ***employment***, similar positive effects expected as under CERT 1, with a greater positive impact on laboratories considering that CERT 2 would require more testing than CERT 1 (to a small extent, some of these costs would be counted under MON, as aforementioned in the economic costs description).

As under CERT 1, social impacts are dependent upon the behavioural response of landowners due to the voluntary nature of the measure.

8.3.3 Distribution of effects

Under this Option, public authorities would be required to invest reasonable financial and time resources into the set-up of a functioning Soil Health Certificate system in the short-term, including the registry. On the compliance side, the stakeholders expected to be most affected are landowners of agricultural, forestry or industrial land who wish to sell their properties. Costs may be higher for owners of larger properties, as more samples would need to be tested. The voluntary nature of the measure means that these stakeholders may choose not to obtain a certificate, but this decision may place them at a competitive disadvantage against other sellers who have obtained a certificate.

8.3.4 Risks for implementation

- Agriculture and forest land changes hands less often (e.g. relative to industrial sites), which reduces effectiveness of this measure (e.g. relative to CERT1)
- Sellers of land where soil health matters less (e.g. developers) would have a lower incentive to comply with the measure
- The cost and simplicity of this measure (for landowners) is dependent on the granularity at which SHSD / MON are undertaken. If the information from SHSD / MON is too high level, landowners would incur additional costs related to soil testing (organizing the accredited laboratory to come take samples, sending results to the competent authority). Where this is significant, this may significantly curtail uptake of the voluntary certificates, in particular where other means exist to understand (although to a more limited extent) the condition of the soil.
- Given links / synergies with SHSD / MON / SSM, the risks from those measures cascade through to here – namely it is challenging to define what good health is (more so than contamination, which itself is still contentious). To then put that in a certificate which affects people’s land values at this stage can represent a risk

- Also risk of certificate is that information contained is not understandable for land owners, and they lack an understanding of what action they can take to improve land
- Speed of transaction – in particular where SHSD/MON do not provide the information for the certificate, there is a significant risk around speed of transaction – i.e. needing to arrange sampling/ lab tests/ results.

8.3.5 Links /synergies

CERT 2 would have a strong synergy with SSM Option 2 and REST Option 2. The Soil Health Certificate is a 'soft' incentive measure for farmers & foresters to engage into sustainable soil management, and hence less coercive than obligations / bans at national or EU level. Significant restoration work is likely to be finalised by 2050, but certificates may bring some activity forward and lead to additional benefits given testing on a more granular stage. CERT 2 could also be implemented in parallel to SSM Options 3 or 4, either in its proposed form or by giving the EC a more prominent role (e.g., by defining what should be in the Certificate, the soil health thresholds, etc.). While under SSM Options 3 and 4, some sustainable soil management practices would be mandated, CERT 2 could still be useful to give information about soil heath and as a complementary incentive to care for soils.

SHSD will develop the indicators on which certificates / 'good health' will be defined, so the complexity defined in that building block will cascade to certificates. CERT 2 best aligns with the Option 2 of SHSD in which indicators are determined by Member States, but would also be complementary to Options 3 and 4.

MON will obligate Member States to collect information on soil health, but – as noted above - additional costs will depend on at what level 'districts' are drawn – where these are at land owner level, then SHSD/MON provide the information needed for the certificates. Where more aggregate, CERT2 will have much higher costs as much more data will need to be collected for each transaction. However, this is also a synergy, as submitting soil health data to competent authorities under CERT 2 will provide granular information to Member States, benefitting MON.

The benefits achieved under CERT 2 will overlap with those achieved under the REST, SSM and NUT building blocks, respectively in terms of remediation and restoration of contaminated sites, improvement in sustainable soil management practices, and contribution to achieving nutrients target.

8.3.6 Summary assessment against indicators

A small indirect impact on soil health can be expected if landowners restore / remediate land in order to obtain a certificate showing it is in good health (agri / forestry) or non-contaminated. This would be dependent upon uptake of the voluntary measure, which itself is dependent on the benefits (positive impacts on land value) vs costs of the measure for landowners. A high uptake would lead to increased benefits but also increased costs for landowners, a vice versa for a lower uptake. A small positive effect on information gains can be expected as this measure seeks to increase awareness on soil health and will contribute to gather granular data on contaminated sites and soil health.

Furthermore, moderate indirect adjustment costs (for testing by landowners, and administrative costs for the EC) can be expected, however, national public authorities can compensate their costs by making people pay for the issuance of certificates. Adjustment costs may be high in certain instances (depending on the area of land to be tested). An additional, small administrative burden can be expected for the Commission and Member States to establish and maintain the certification system. However, a much larger administrative burden is also anticipated where the monitoring programme implemented under MON is not sufficiently granular to assess soil health at the granularity of individual landowners – in this case, MON could not directly provide information as an input to the certificates, and land owners would be required to undertake additional testing at significant cost.

Finally, the certification system can be expected to incur small positive impacts on the on distribution of costs and benefits as this measure will influence the price of a property based on soil health, ensuring the polluter is financially penalised and does not pass on the contaminated soil to an unaware buyer.

Table 8-7: Overview of impacts

Effectiveness	**Impact on soil health**	(+)	Indirect benefit where landowners restore soil to good health and/or take additional action to maintain good health status throughout their tenure.
	Information, data and common governance on soil health and management	+	Option will increase awareness of soil health in land owners and prospective buyers as this information becomes a visible part of the process and documentation around land transactions, hence improving data and information available. Potential benefit lower than other options due to implementation risks.
	Transition to sustainable soil management and restoration	(+)	Indirect benefit where landowners restore soil to good health and/or take additional action to maintain good health status throughout their tenure.
Efficiency	**Benefits**	+	Improvement of data and information is key benefit.
	Adjustment costs	**0**	No direct adjustment costs
	Administrative burden	---	Option implies large (> EUR 5m pa) ongoing administrative cost for Member States to manage and maintain system to issue certificates and for soil testing at each site
	Distribution of costs and benefits	+	Small positive effect as certificate will influence property value, better reflecting the polluter pays principle
Coherence		+	Restoration of all sites already mandated under REST, so benefits (and costs) overlap. But could complement REST in that some remediation activities are brought forward.
Implementation risks		--	Several risks limit potential achievable benefits: uptake is voluntary; only impacts where land is sold; and added value uncertain given some elements already captured in existing due diligence.

9 SOIL PASSPORT (PASS)

9.1 Overview

9.1.1 Building block outline

The following add-on seeks to establish a common obligation for the proper treatment of excavated soils (from construction and demolition projects), which could take a form in a digital soil health passport. This passport will inform stakeholders on the health of excavated soils and allow them to potentially reuse the soil.

9.1.2 Problem(s) that the building block tackles

One of the main drivers impacting soil health is the increasing rate of soil sealing and land-use change, which consequently leads to significant quantities of soil being excavated. Excavating soils is necessary for construction projects like water and sewer piping, repairing foundations, power line construction or other structural construction work. Depending on local geological conditions and anthropogenic activities, excavated material can be rock, stones, gravel, sand, clay, organic material and other materials from previous constructions or industrial activities. The soils extracted (both clean and contaminated) from these activities are one of the largest sources of waste produced across Europe in volume[845]. For example, in France it is 150 million tonnes each year which is equivalent to 5 times the amount of household waste. Currently, excavated soils are considered to be waste under the Waste Framework Directive[846] and are therefore often disposed of in landfills. This is further confirmed by data from Eurostat. In the EU in 2020, there was a total of 434.6 Mtonnes of non-hazardous soils excavated, of which 154.8 Mtonnes (i.e. 35.6%) were recycled and thus used for their biological properties and capacity to provide ecosystem services, eliciting the existence of dedicated soils recycling companies.[847] Consequently, 173 Mtonnes of non-hazardous excavated soils were used for backfilling, i.e. only for the volume that they occupy, and 106.6 Mtonnes simply landfilled, in both cases having their biological productive capacity wasted.[848]

However, there are large discrepancies between countries. For example, Norway sent 98% of non-hazardous excavated soil to landfill in 2018, while Portugal just sent 17% (in 2017)[849]. These noticeable differences have further been confirmed by stakeholders' responses to targeted consultation. It was indicated that in Austria approx. 25% of excavated soil classified as waste is reclaimed for backfilling (NB: non-contaminated soil on site is not classified as waste and is -reused), while in Belgium nearly 90% of excavated soil is being reused.[850]

Therefore, ensuring excavated soil is reused more consistently and safely can be desirable, depending on the location (e.g. it is assumed that in densely populated urban areas, where demand for soil might be higher than in rural areas).[851]

Based on the above, PASS can be linked back to **Sub-problem B:** Transition to sustainable soil management and restoration is needed but not yet happening. This is due to the following drivers:

- Incomplete EU framework; and,
- National and EU laws do not effectively promote sustainable soil management, agricultural, forestry and other practices where soil is being handled (e.g. construction in relation to excavated soils).

[845] https://www.euractiv.com/section/circular-economy/news/excavated-soils-the-biggest-source-of-waste-youve-never-heard-of/
[846] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098
[847] E.g.: https://www.boughton.co.uk/soil-collection-recycling-services/
[848] Eurostat (2022) Treatment of waste by waste category, hazardousness and waste management operations[env_wastrt]
[849] The_Reuse_of_Excavated_Soils_from_Construction_and_Demolition_Projects_Limitations_and_Possibilities
[850] As per feedback from Austrian Competent Authority and a Belgian industry association to targeted stakeholder consultation.
[851] EEA (2016) Soil resource efficiency in urbanised areas. Analytical framework and implications for governance

9.1.3 Baseline

At the EU-level there is limited regulation or legislation on the proper treatment of excavated soils – the soil health passport is a novel idea at EU level.

At EU level, the Waste Framework Directive (WFD, 2008/98/EC) is typically the starting point for the reuse of excavated soils. This Directive seeks to “help move the EU closer to a ‘recycling society’, seeking to avoid waste generation and to use waste as a resource”, and specifically states that 70% of construction and demolition waste (CDW), to which excavated soil belongs, should be recycled by 2020.[852] Following this, as part of the EU action plan for circular economy the “EU Construction & Demolition Waste Management Protocol” (European Commission, 2016) and “Guidelines for the waste audits before demolition and renovation works of buildings” (European Commission, 2018) were prepared, however, clean or lightly contaminated excavated soils were not included within its scope. In 2020, the European Commission published a report: “Circular Economy Action plan for a cleaner and more competitive Europe”.[853] Within this report, a new strategy for a sustainable built environment is outlined and one goal is “promoting initiatives to reduce soil sealing, rehabilitate abandoned or contaminated brownfields and increase the safe, sustainable and circular use of excavated soils.”

At Member State level some countries have introduced legislation targeting the reusage of excavated soils. For example, the Netherlands (het Besluit activiteiten leefomgeving (Bal), het Besluit bodemkwaliteit (Bbk)),[854] France (Prévention de la pollution des sols – gestion des sols pollués)[855], and Flanders (Grondverzetsregeling)[856] have legislations in place that follow the standstill and fit-for-use principle. This means that excavated soil cannot be used if this would result in the deterioration of the environmental situation or an increased risk for human health and the environment (standstill); and that excavated soils can only be reused when its quality is suitable or fit for the function or land use on the receiving site (fit-for-use). Besides this, all three Member States use a traceability system which requires excavated soils above a certain volume to be reported to a national register (France and the Netherlands) or a soil management organisation (Belgium), this allows for transparency on the re-usage, the origin, the destination, quality, and quantity of excavated soils.

9.2 PASS – 1 – Proper Treatment of excavated soils

9.2.1 Description of option and requirements for implementation

The first Option under the Soil passport add-on (PASS 1) refers to an establishment of a common obligation to ensure proper treatment of excavated soils.

The **formulation of the option** allows for two levels of ambition:

- 1a) Under the first formulation, the Soil Health Law would introduce a **general, high-level EU requirement** which would oblige Member States to ensure

[852] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098
[853] https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en
[854] https://iplo.nl/thema/bodem/regelgeving/hergebruik-bouwstoffen-grond-baggerspecie/regelgeving-hergebruik-bouwstoffen-grond/
[855] https://www.bulletin-officiel.developpement-durable.gouv.fr/documents/Bulletinofficiel-0005403/eat_20070013_0100_0065.pdf;jsessionid=B44AF53D123DD15E16DF784AC25B14F0
[856] https://ovam.vlaanderen.be/gebruik-van-bodemmaterialen-grondverzet#:~:text=In%20de%20grondverzetsregeling%20wordt%20bepaald,artikel%20171%20van%20het%20VLAREBO).

proper treatment of excavated soils, following the principles of standstill and of fit for proper use. The exact **definition of 'proper treatment of excavated soils' would be left up to Member States**, to ensure that the specificities of each region can be reflected within the definition. At the same time, however, the definition should be based on common criteria set at EU level, to ensure a level of coherence across Member States. Furthermore, the **means of implementation** and of achieving the proper treatment would also be **defined by** individual **Member States**.

- 1b) The second formulation would require a slightly higher level of harmonisation at EU-level. In this case there would still be an **EU-level requirement** which would oblige Member States **to ensure proper treatment of excavated soils**, following the principles of standstill and of fit for proper use would remain. In addition to this, there would be a common, **EU-level definition of 'proper treatment of excavated soil'**. Nevertheless, similarly to the first formulation, the **means of implementation** and of achieving the proper treatment would **remain with Member States**.

The purpose of establishing an obligation of proper treatment of excavated soils is to allow for potential re-use of this soil, in cases when the soil remains uncontaminated. Before soil is excavated it should be tested, as is currently done in Belgium and France. In Belgium, a so called 'technical report' must be filed stating whether the soil is contaminated or not[857] (for example for soils with a volume larger than 250 m^3). In France, the reuse of excavated soils outside of the site is allowed but a mandatory requirement is that it is tested (for contamination) before it is used. In the case of contaminated soil a similar approach as in the Netherlands could be followed: If the soil can be cleaned this should be done (liability lies with the polluter), if you are unable to clean or immobilise contaminated soil, you may dump the soil if you have a non-cleanability statement for contaminated soils.[858]

For each formulation there would also be a possibility on setting a common, EU-level target on how much excavated soil should be reused. However, when setting the target, a number of elements should be considered, namely the size and specific (local) conditions of individual Member States. For example, in Member States comprised mostly of urban areas the rate of reuse of excavated soil could be higher than in Member States with larger rural areas, due to the fact that densely populated Member States can have a higher demand for reused soil rather than Member States with larger rural areas. Therefore, if a target for reuse is to be set this should be proportionate to the size and specific situation of each Member State.

The option under PASS 1 can function as a standalone option, EU-level requirement for proper treatment, or accompanied by PASS 2, which amounts to an implementation tool.

Formulation 1a (EU-level requirement for 'proper treatment of excavated soils', where Member States define 'proper treatment') would entail the following implementation activities:

- European Commission:

[857] https://ovam.vlaanderen.be/wanneer-is-er-een-technisch-verslag-nodig
[858] https://business.gov.nl/regulation/dumping-sites/#article-soil-protection-for-landfills

- The European Commission must introduce a provision within the Soil Health Law, requiring that Member States ensure proper treatment of excavated soils.

- Member States
  - Member States are to develop a definition of ‘proper treatment’ of soils. When doing so, Member States are expected to draw upon a number of common criteria developed by the European Commission, which consider differences between Member States in relation to practices in agriculture, forestry, land use, etc., but at the same time ensures a level of coherence at EU-level
  - Member States are to create a mechanism for implementation, that obliges relevant stakeholders (e.g. developers, land managers, farmers, foresters) to ensure the proper treatment; and
  - Member States are to create a mechanism for monitoring to assess the extent of compliance with the obligation. Here, the monitoring mechanism could follow the example under the MON building block, for example with the support of sampling points or algorithms.
- Businesses / industry:
  - Business / industries are to take action to follow the ensure proper treatment.

Formulation 1b (EU-level requirement for ‘proper treatment of excavated soils’, where ‘proper treatment’ is defined at EU-level) would entail the following implementation actions:

- European Commission:
  - The European Commission is to introduce a provision within the Soil Health Law, requiring that Member States ensure proper treatment of excavated soils.
  - In addition, the European Commission is to develop and codify a definition of proper treatment of excavated soils within the Soil Health Law, draw upon a number of common criteria developed by the European Commission, which consider differences between Member States in relation to practices in agriculture, forestry, land use, etc., but at the same time ensures a level of coherence at EU-level
  - The European Commission is to define conditions of treatment, storage and recovery of excavated soil.
- Member States
  - Member States are to create a mechanism for implementation, that obliges relevant stakeholders (e.g. developers, land managers, farmers, foresters) to ensure the proper treatment; and
  - Member States are to create a mechanism for monitoring to assess the extent of compliance with the obligation. Here, the monitoring mechanism could follow the example under the MON building block, for example with the support of sampling points or algorithms.
- Businesses / industry:
  - Business / industries are to take action to follow the ensure proper treatment.

Furthermore, both formulations should be accompanied with guidelines by the European Commission for re-use of excavated soil. In all circumstances, specificities related to implementation, such as storage conditions, would be left up to Member States. The guidance should also specify what the requirements for reused soils are, in order to prevent any barriers to its reuse.

9.2.2 Assessment of impacts

The importance of establishing proper treatment for excavated soils was reiterated during the Call for Evidence, where stakeholders were asked about their opinion on how to address excavated soils. Here, 17 out of 22 respondents expressed support for a common, EU-level approach for the conditions of treatment, storage and recovery of excavated soil as well as setting binding material recovery target for excavated soils. As such, many of the impacts stemming from PASS 1 relate to the re-use of the excavated soil.

As per the results of the OPC there is a considerable support for obligation for Member States to create a soil passport for excavated soil, where many respondents considered such measure either very effective (approx. 40%) or at least reasonably effective (approx. 28%). Out of these stakeholders the largest support (above 40% of stakeholders) for such measure was among environmental organisations, academia, consumer organisations and public authorities.

Economic

As outlined in literature[859], reusing excavated soil offers the following direct economic benefits:

- reduction in transportation distance to re-use sites as opposed to landfill, with a consequent impact on transportation costs, and other environmental externalities (e.g. GHG and air pollutant emissions), depending ultimately on where the excavated soil is re-used,
- reduction in costs associated with disposal (Stakeholders also indicated the costs associated with when excavated soil cannot be reused and must be brought to a landfill. These are approx. EUR 60-65 (EUR 35 amounting for a tax and EUR 30 costs of disposal))
- preservation of landfill capacity, with a knock-on effect of reducing the costs and environmental pressures of developing new landfill capacity.

Other economic benefits of reusing excavated soil off-site (in other projects) would relate to transport and the use of energy. In Finland there were projects ongoing in the same region (approx. 50 km distance from each other). The benefit of re-using the excavated soil on other sites rather than landfilling it in the same region resulted in the following benefits - an increased reuse of totally 30 000 m^3 of excavated material and emission reductions of about 100 tons of CO_2. Furthermore, transportation, landfilling, and use of new construction material were reduced - the benefits of reusing excavated soils in other projects resulted in total project savings of approximately 30% in these costs.[860]

With regards to ***administrative burden/cost***, some costs are expected for the European Commission, Member States and the industry. As outlined in the 'implementation activities' section, the European Commission, aside from introducing the obligation, will likely be developing a guidance for the re-use of excavated soil. Based on the consortium's experience in developing guidance documents for the European Commission, stemming for example from the study prepared for the revision of the Urban Wastewater Treatment Directive (UWWTD), this could be expected to cost

[859] The Reuse of Excavated Soils from Construction and Demolition Projects: Limitations and Possibilities - Sarah E. Hale

[860] https://www.sciencedirect.com/science/article/pii/S0959652615000141#bib33

around EUR 500 000 (i.e. elaborate guidance document). Thereafter, adjustment costs at a Member State level would firstly depend on the current level of implementation by Member States relative to the objectives in the guidance document (the implementation gap). Based on the feedback received from stakeholders through the targeted consultation questionnaire, it appears that at least 7 Member States already have some practices in place on reuse of excavated soil. As such, those Member States would likely face lower adjustment costs than those with none to limited efforts on reused of excavated soils. Secondly, the adjustment costs would also depend on the extent to which Member States choose to implement the guidance document. Furthermore, Member States would likely face some costs in relation to monitoring. Currently, approx. EUR 1 350 000 one-off and recurring costs for all Member States were anticipated.

Lastly, it is anticipated that there would be some ***adjustment costs*** to ensure proper treatment. As per targeted consultation carried out with stakeholders, the following costs associated with proper treatment have been indicated by stakeholders:

- Costs of assessing the quality of excavated soil: approx. EUR 1 per tonne;
- Costs of cleaning the excavated soil: approx. EUR 30-40 per tonne (and if costs are higher than EUR 75 per tonne then the given soil is considered economically not interesting to clean); and
- Costs of reuse the excavated soil:
  - If direct reuse is possible then costs are between EUR 0 and 5 per tonne; or
  - If indirect reuse is not possible and the soil needs to be stored (in, so called, ‘soil banks’), the associated costs are EUR 5-10 per tonne.

Using the Eurostat data mentioned above on how much excavated soil is diverted from landfill and reused and the costs provided by the Dutch authorities the costs and benefits for businesses of treatment of excavated soil can be calculated. Assuming that a given share (35% of the soil currently landfilled would be re-used because of PASS 1) of the 173 Mtonne / year of soil that is currently landfilled in the EU would be re-used instead it can be estimated that there would be EUR 1.8 billion of economic benefit in the EU annually.

Environmental

As outlined in literature,[861] reusing excavated soil offers the following direct environmental benefits:

(1) conservation of non-renewable natural resources (namely: soil), and
(2) reduction of environmental and ecological impacts.

The most significant environmental gains would amount to a ***more efficient use of (non-renewable) resources***. This would be associated with reuse of excavated soil on site. As mentioned above, 173 Mtonnes of non-hazardous excavated soil was not recycled in the EU in 2020. With an obligation to do so this additional volume of soils would be recycled instead of being landfilled or backfilled, and hence its capacity to ensure high-value ecosystem services would be maintained.

The reduction of environmental and ecological impacts is demonstrated by a case study taken from the literature,[862] whereby planning for mass balance of earthworks in an

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[861] The Reuse of Excavated Soils from Construction and Demolition Projects: Limitations and Possibilities - Sarah E. Hale

[862] Sustainable management of excavated soil and rock in urban areas – A literature review https://www.sciencedirect.com/science/article/pii/S0959652615000141#sec3

industrial construction project, it was possible to relocate and reuse 44% of the excavated materials (i.e. about 700 000 m^3), and hence reduce earthwork and transports to landfill as well as the production and use of quarry materials. The total climate impact from reduced transportation in this example was estimated to result in a reduction of about 4,000 tons of CO_2 from fuel savings, which would also benefit economically. A reduced risk of using contaminated soil elsewhere can also be expected.

Social

Minimal social impacts can be expected, solely relating to the administrative requirements to develop the obligation itself. Further, this intervention would be expected to indirectly benefit society (indirect impacts on ecosystems, climate, reduced flood risks, costs to society and societal benefits and burden sharing).

9.2.3 Distribution of effects

The stakeholders who would be most impacted by the introduction of a requirement on proper use of excavated soil would likely be those who are directly involved in the excavation and potential re-use of the soil, namely industries in the following fields: resource extraction and construction, land-fill operators, transport businesses, etc. Many of these actors will face some burden to consider the reuse of excavated soils. However, the benefits may very well outweigh this burden. For example, resource extraction and construction companies may save costs by not paying to landfill their soil (in a site that may be far away), but instead receiving money for transporting the soil to the location of reusage.

9.2.4 Risks for implementation

The key risk for this option is around the definition of ‘proper treatment of excavated soils’ itself, particularly its scope, whether it would include a binding target for re-use of soils, etc. The formulation of these aspects will likely directly impact the measures which are undertaken by Member States to achieve proper treatment of excavated soil. Moreover, defining an EU-wide definition could pose challenges as some Member States already have a definition in place, this means that there are transition risk for these countries. Closely related to this, there is a risk that definitions diverge and are inconsistent. For example, Norway considers excavated soil per definition as waste material while France treats contaminated excavation sites as ‘contaminated sites’ and uncontaminated excavations sites as ‘natural materials that can be (re)used in earthmoving programmes if they satisfy certain geotechnical considerations[863]. Therefore, there will be a need to establish a common consensus of the definition, which not only reflects existing practices, but allows stakeholders to understand how to implement actions towards reuse of excavated soil, as well as the general public to comprehensively understand the issue. Such consensus will likely facilitate the uptake of the definition.

Lastly, there is a risk associated with setting a target. Member States may feel obliged to reach the targets and therefore start reusing contaminated soils as a means to get there. On the contrary, not setting a target may result in a decline of the reusage, encouraging landfilling as this is cheaper than storing soils.

[863] https://www.mdpi.com/2071-1050/13/11/6083/htm

Besides risks for implementation of the obligation, barriers to re-use of excavated soil can also be identified. For example:

- Lack of holistic and early planning for possible reuse (preparation of applications, synergies with other projects, etc.);
- Demand of excavated soil may not always match with supply (and vice versa), in particular given the weight of excavated earth limits the geographical range over which soil can be re-used before costs become prohibitively expensive;
- Lack of intermediate storage (on and off-site) and limitations on how long Member State legislation allows for (uncontaminated) excavated soil to be stored (e.g. in the Netherlands there is a 3 year limit on how long soil can be stored; once this period has passed the storage is legally classified as landfilling)[864]; and
- Material quality barriers (preference for primary materials in general (not just for soil).

9.2.5 Links /synergies

This Option (PASS 1) builds on the SSM building block. The definition of 'proper treatment' is directly based on the list of criteria for sustainable management practices. There is also a link with the SHSD building block, which defines 'healthy soil' and with the DEF building block, which defines levels of contamination.

Furthermore, there is also a link to the LATA add-on, and any subsequent action around land take, given excavated soil is often the result of land-take activities. It is presumed that the obligation for proper treatment of excavated soil would not work if the land take definition wouldn't be set accurately.

9.2.6 Summary assessment against indicators

With regards to effectiveness, very limited to no direct impact on soil health itself is expected. The option at hand will not improve the health of the excavated soil as such, instead it will ensure that, where possible, the (uncontaminated) soil is reused. On the other hand, it will play an important role in the transition to sustainable soil management, for exact this reason of uncontaminated soil being reused where possible. If PASS 1 is introduced in combination with PASS 2 it will also have a direct positive impact on harmonisation of collection and sharing of existing data on soil and ensure a level of common governance in soil management across the EU.
It also appears to be a reasonably cost-efficient measure, with quantifiable positive economic and environmental impacts. Nevertheless, some implementation risks remain, namely around the formulation of proper treatment, setting a target for reuse. Furthermore, implementation would need to take into account that some Member States already have a similar obligation in place, in order to prevent any transition risks/double obligation etc.

Table 9-1: Overview of impacts

Effectiveness	**Impact on soil health**	**0**	Option has very limited to no direct impact on the health of soil

[864] As per feedback from Dutch Competent Authorities to targeted stakeholder consultation.

			itself in situ.
	Information, data and common governance on soil health and management	+	Effective implementation requires a mechanism in place to attain information on the status of the soil, and share this will the excavator and potential onward users, hence improving data and information around soil health.
	Transition to sustainable soil management and restoration	+	Option aims to, where possible, encourage reuse of (uncontaminated) soil and prevents the further and complete deterioration of that soil if not properly handled and re-used. Benefits anticipated to be small given risks to implementation
Efficiency	**Overall benefits**	+	Improvement in data and transition to SSM are key benefits.
	Adjustment costs	+/-	Adjustment costs for setting up storage facilities. But reusing excavated soil offers several economic benefits, such as reduction in transportation distance to re-use sites
	Administrative burden	--	Moderate (between EUR 1m and 5m pa) ongoing costs for Member States to oversee re-use of soils.
	Distribution of costs and benefits	+	Those most affected will be those involved in the excavation and potential re-use of the soil. Many of these actors will face some burden to consider the reuse of excavated soils, but will also accrue economic benefits.
Coherence		+	Passport could be deployed as a mandated practice under SSM.
Implementation risks		--	Several risks may limit benefits in practice: economic feasibility of re-using soil is limited by high transportation costs; re-use depends on development of storage and demand side.

9.3 PASS – 2 – Content and format of passport

9.3.1 Description of option and requirements for implementation

The following option aims to establish a digital soil passport with technical features defined at EU level, including obligations for Member States. PASS2 is a facilitating measure to complement PASS1. Essentially this means that proper treatment of excavated soils can be achieved through establishing a digital soil health passport, that ensures traceability and reusability of excavated soils.

This passport will take Member States' experiences into account and will reflect the quantity and quality of excavated soil to ensure that it is transported, treated and reused safely somewhere else. The main features of this passport and the usage of the standard when regulating the excavation of soils are to be defined in the Soil Health Law, while the relevant European Standardisation Organisation (CEN or Cenelec, depending on whether the focus lies on the content of the passport or on the technical means to implement it with digital means) will be mandated to define the technical standards.

To establish an EU digital soil passport that functions across all Member States, the EU and the relevant European Standardisation Organisation will determine the features of the digital soil passport. The minimum requirements on information to be included at the EU level would be:

- Geographic origin;
- Type of soil;
- Date of excavation;
- The values of the soil health descriptors levels upon excavation;
- Quantity of soil;
- Future use of excavated soil;
- Validity period.

As the passport should also address the cross-border transfer of excavated soils, the requirements of the passport will be defined at an EU level to ensure a harmonised approach across Member States.

The soil passport will require the European Commission to take on some responsibility, especially with regard to:

- Identifying the soil health descriptors (links to SHSD), they will relate to the chemical, physical and biological properties of soils. Member States would have the liberty to impose more stringent requirements with regard to the values set for the soil health descriptors.
- Defining a threshold value for the quantity of excavated soils above which soil passport will be mandatory.
- Define the requirement for validation by certified third party (if any).
- To set an obligation for operators to ensure proper treatment of uncontaminated and contaminated excavated soil as under PASS1b and REM, with the specificity on determining who does what set at the Member States level.
- Setting up the IT infrastructure enabling Member States to upload their country data.

In addition, Member States, will also be required to take several actions:

- Obligation for Member States to set up the record of the use of excavated soils excavated on their territory in the form of a Digital Soil Passport, under the format standardised at EU level (so that the information contained in the Digital Soil Passport be usable even if that excavated soil is subsequently moved to another Member State). Subsequently, this should be recorded and reported to the European Commission for inclusion in the EU Digital Soil Passport.

Member States will be responsible for setting specific requirements of the passport, for example:

- Determining who (owner excavated site vs owner receiving site):
  - Is responsible for the application for the passport
  - Is responsible for the quality testing and assurance (determined under PASS1)
  - Is responsible for the use or reuse of the soil (determined under PASS1).
- Determining the manner in which excavated soils should be transported and stored.
- Determining what third parties will be allowed to certify and validate the passport
- Setting up a function to issue passports and ongoing administration of this function (including enforcement around non-compliance)

9.3.2 Assessment of impacts

Economic

The economic impacts captured under PASS1 would also accrue to PASS2. Beside these effects the introduction of a soil passport will bring an additional ***administrative burden***. It is expected that this will require economic operators (people that excavate the soil) to collect, store and make available the information regarding the state of the excavated soil. As a result, an increase in costs for economic actors can be expected. That said, the same information would likely already be collected under PASS1, and some the information needed for the soil passport such as the soil health descriptors may already be available under obligation to monitor (as per the MON building block) however depending on the choice on how districts are defined, this information is very likely not to be of sufficient granularity for inclusion in the passport.

Economic actors would also incur costs associated with applying for the passport and recording use of the excavated soil in the passport. In Flanders, the costs for businesses to register excavated soils in a national database were approximately €0.05 per cubic meter of soil. Besides this the associated savings amounted to €2/m^3 in avoided costs related to landfill taxes and waste transportation.[865] Economic actors would also incur costs associated with third party verification.

Furthermore, there will be an administrative burden for Member State competent authorities related to setting up the process and structures to manage and issue applications for the passport.

At the EU-level, an administrative burden can also be expected, due to the need for the creation of an IT infrastructure to manage and collate all the digital soil passports. One way in which such an infrastructure could be set up is through an Electronic Data Interchange (EDI), where the seller and buyer of excavated soils could interact. Concerning costs, setting up such a system that either interconnects national electronic notification systems or replaces those systems with an EU-wide system will generate costs both in terms of establishment and in terms of maintenance of the system. These costs would have to be shared between the EU and the Member States. In the case of an interconnect that links national systems the costs related to the EU component (central routing component, EU platform) would need to be financed from the general budget of the EU, whereas Member States would bear the costs needed for the adjustment of their national systems to make them interoperable with the EU system.

Linking the national systems with an EU central system has been done in the past (with bank accounts in 2019)[866] and depending on the complexity of the system the costs of setting up such a network were estimated to be approximately 2€ million, with annual maintenance of costs of €150,000. The cost of participation by countries in this system is approximately €20 000 per country, per year. This provides an indication of what the costs for setting up the IT infrastructure for the digital soil passport could look like.

If the same costs as for establishing the soil health certificate are presumed, then the costs for the establishment of PASS2 would be as follows per stakeholder type:

- EC: EUR 290 000 of one-off costs;
- MS: EUR 50 000 000 of one-off costs and 7 500 000 of recurring costs; and
- Others: approx. EUR 6 000 000 of recurring costs.

Costs for an already existing ‘excavated soil registering system’ in the Netherlands have been indicated as follows: initial costs for establishing such register are approx. EUR 400 000, with annual maintenance costs of approx. EUR 100 000 and half of FTE. In addition to these costs, it has been indicated that there additional costs for users and controllers, though these were not specified.[867]

Lastly, the Digital Soil Passport may have a positive effect on technological development (***Technological development/ digital economy***). For example, large-scale requirements on monitoring and on soil remediation can create a market for innovative technologies, including digital technologies. For example, there is a Canadian company called

[865] https://www.euractiv.com/section/circular-economy/news/excavated-soils-the-biggest-source-of-waste-youve-never-heard-of/
[866] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52019DC0372
[867] As per feedback from Dutch Competent Authorities to targeted stakeholder consultation.

FillConnect[868] connecting people in search of excavated soils and people getting rid of their excavated soils through their digital marketplace platform, which is a good example of such a technological development.

Environmental

The direct environmental impact of a digital soil health passport (over and above the benefits of re-use of excavated soil captured by PASS1) is expected to be limited. However, if it is set up effectively and is enforced across all Member States, it could have a positive influence on the re-usage of excavated soils. By having a system in place that allows for traceability, where uncontaminated excavated soils can be identified from early on, reusage can be encouraged. In addition this would allow for the identification of contaminated soils, which could then be treated. Ultimately, this could reduce the dumping of soils in landfills and promote reusage. Flanders has a soil settlement regulation that ensures usability of soil materials as raw materials for building materials/products, which significantly benefits the environment as 95% of excavated soils are reused.[869] In order to improve uptake of the soil health passport, strict monitoring and a well-functioning traceability system will have to be put into place. In Flanders this is done through mandating a prior soil investigation (technical report). This ensures that no polluted excavated soils are reused in other destinations, reducing harm to the environment.

Besides this, a digital soil passport is likely to encourage the reusage of excavated soils as it will be easier to trace and obtain excavated soils. As a result, a more 'circular' system will prevail meaning less soils will be dumped in landfills. As landfills produce carbon dioxide and water vapor, and trace amounts of oxygen, nitrogen, hydrogen, and non-methane organic compounds a reduction of landfill dumping will have a positive impact on the ***climate***.

The Digital Soil Passport supports the reuse of excavated soils and thus the reduction of its disposal. It contributes significantly to the reduction in ***waste production and promotes recycling*** of excavated soils.

Social

The impacts of PASS2 are anticipated to be similar as to those under PASS1.

9.3.3 Distribution of effects

The impacts of PASS2 are anticipated to be similar as to those under PASS1. The groups most likely to be affected are the ones that actively participate in soil sealing and land take activities- namely: industry, commercial entities, real estate developers and construction. These groups are most likely to apply for a soil health passport and therefore face the administrative burden associated with obtaining one.

9.3.4 Risks for implementation

In addition to the risks associated with PASS1 as set out above, there is a significant risk that each of Member States use a different, incompatible technical system to store data.

[868] https://fillconnect.com/
[869] https://bouwen.vlaanderen-circulair.be/en/cases-in-flanders/detail/grondbank

As a consequence, there may be standardisation issues. The issue of standardisation, at the detailed level of inter-operability of the storage and transmission of data, is considered to be an essential feature of the Digital Soil Passport.

There is necessity for clear requirements on soil monitoring in order for the digital soil passport to be useful. As a lack of scientific evidence consensus over what soil descriptors should be included in the digital soil passport would be detrimental to its success. Therefore, it is key to establish a clear definition as to what 'soil health' is. There is a risk that not all elements of soil health can be captured under the passport which could undermine the effectiveness.

The granularity at which the soil districts are selected also plays a key role. If these are very aggregated, then monitoring will not provide information at the site level. As a result, the responsibility falls upon the land developers to perform the sampling procedures which bring an additional cost and time burden. The usage of passport could then slow down the development activities and this could incentivise land developers to landfill as this is the easier option. Thus, the success of the passport is conditional to the granularity at which the soil districts are defined and the success of establishing adequate monitoring requirements.

Another key risk relates to whether a market for healthy excavated soils will in fact arise. It could be the case, that even with a digital soil passport, there is no demand for excavated soils. This would mean that the excavated soils are landfilled and defeats the purpose of the soil health passport.

9.3.5 Links /synergies

The soil passport is closely linked to the monitoring building block (link to MON), because depending on the chosen Option certain soil descriptors will have to be monitored, measured and recorded. The results of these measurements could feed into to the contents of the soil passport directly, establishing whether the soils are healthy (link to SHSD) and/or contaminated (link to DEF) or not. This would be determined based on the ranges that are defined in the monitoring building block.

9.3.6 Summary assessment against indicators

The direct impact on soil health from PASS2 is limited as it does not directly address soil health; its focus is on the reusage of excavated soils. The use of a passport may have a small positive impact on the environment by reducing landfilling (positive effect on the climate through reduction of GHG emissions) and promoting recycling as well as reducing waste generation. Furthermore, establishing a Digital Passport on excavated soils will improve the information and data on soil health as well as positively affect sustainable soil management (through the reuse of soils instead of landfilling). In addition, the passport is expected to have an economic impact on the users and the EU especially in the form of an additional burden for setting up the IT infrastructure. These costs would consist of a potential transition cost for Member States, setup cost for the EU and maintenance costs for the EU. Overall, the Digital Soil Passport is linked closely to the SHSD and MON building blocks. These two are essentially conditional to the success of a Digital Soil Passport. Moreover, a few implementation risks will maintain with regard to ensuring that all Member State systems (if they exist) are compatible with the EU system, granularity of the soil districts and the risk of a market failing to arise.

Table 9-2: Overview of impacts

Effectiveness	**Impact on soil health**	**0**	Option has very limited to no direct impact on the health of soil itself in situ.
	Information, data and common governance on soil health and management	++	Digital passport following EU-wide template delivers a greater improvement in data and information (relative to PASS1) as data likely to be more consistent in collection, presentation and reporting.
	Transition to sustainable soil management and restoration	**0**	Digitalisation will have no additional, direct impact (on top of PASS1)
Efficiency	**Overall benefits**	++	Improvement in data is the key benefit.
	Adjustment costs	**0**	Digitalisation implies no additional adjustment costs
	Administrative burden	---	Large (> EUR 5m pa) ongoing burden to manage and maintain IT system issuing passports, and for third party verification.
	Distribution of costs and benefits	**0**	No material impact on distribution of effects.
Coherence		**0**	No material impact on synergies with other options.
Implementation risks		**0**	PASS2 would not necessarily bring in any additional delivery risks over and above those of PASS1

10 NUTRIENTS TARGET (NUT)

10.1 Overview

10.1.1 Building block outline

The Commission committed in the Biodiversity and Farm to Fork Strategy[870] to act to reduce nutrient losses by at least 50%, while ensuring that there is no deterioration in soil fertility. This will reduce the use of fertilisers by at least 20% by 2030, relative to 2012-2015. The Commission will adopt an Integrated Nutrient Management Action Plan in the beginning of 2023 with measures to reduce nutrient losses (part of the baseline). Member States will identify nutrient load reductions through the application of balanced fertilisation and sustainable nutrient management. The two primary nutrients which are of concern are nitrogen and phosphorus. This building block aims to assess the impact of setting a legal basis for the target.

10.1.2 Problem(s) that the building block tackles

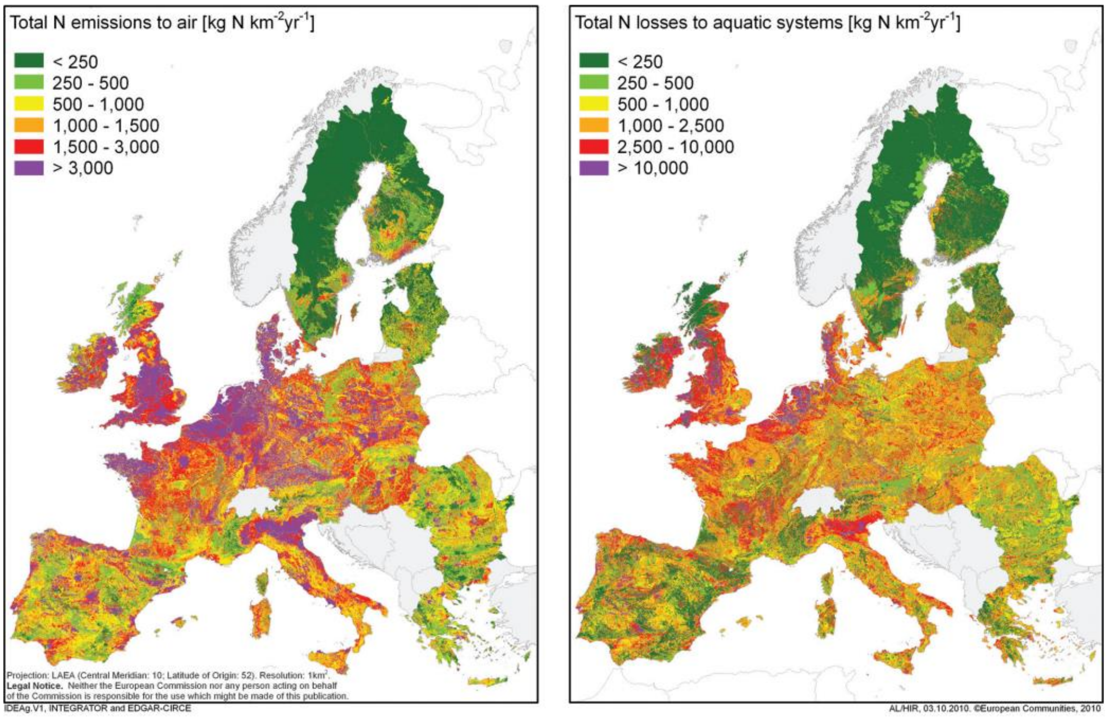
Despite reducing nutrient losses resulting from several Directives (for example, the Water Framework Directive, the National Emission reduction Commitments Directive (see annex 8), there are still significant impacts from nutrient losses occurring across Europe.

The estimated distribution of overall reactive nitrogen[871] losses to the environment is shown inFigure 10-1. Increases in nitrogen in water poses direct threats to humans and aquatic ecosystems. High nitrate concentrations in drinking water are considered dangerous for human health. Moreover, increasing nitrate in groundwaters threatens the long-term quality of the resource. A value of 1.5 mg N/l has been considered as the total

[870] Farm to Fork Strategy (europa.eu)
[871] Reactive nitrogen includes nitrate, ammonium and ammonia, gaseous nitrogen oxides, nitrous oxide and many other inorganic and organic nitrogen forms.

nitrogen limit above which freshwater bodies may develop loss of biodiversity and eutrophication. Except in Scandinavia and in mountainous regions, this level is already exceeded in most European freshwater bodies.[872]

Figure 10-1: Distribution of reactive nitrogen emissions across Europe (kg N per km^2 for 2000) including emissions to air as NOx, NH3 and N2O and total losses to aquatic systems, including nitrate and other reactive nitrogen, leaching and wastewaters



Source: European's Nitrogen Assessment

Soil, and its management, have an important role in nutrient cycles and their loss to the environment: Nutrient losses can be a consequence of poorly managed soil, or the excessive or exclusive application of nutrients. Soils used for intensive production exhibit much faster organic matter decomposition, and they are less able to store nutrients and carbon. Nutrient losses can also occur from healthy soil, particularly if the management practice increases nitrogen for example legume cover crops. Furthermore, current climate change is predicted to increase the frequency of extreme weather events, potentially leading to severe nutrient leaching, soil erosion and further declines in soil organic matter and soil biodiversity.[873] Although the complex dynamics of soil biodiversity are not yet fully understood, there are indications that chemical fertilizer have a negative effect on the balance of soil life. In particular, pesticide use can have extremely negative effects on soil organisms, and according to some studies, certain fertilizer substantially inhibit bacterial and fungal activity in the soil.

The application of nutrient to soils occur in order to support use of soils to provide a medium for plant growth. While they are therefore the primary recipient of nutrient applications, the drivers for the application of nutrients are mainly centred around the production of food and forage. Soil is a recipient of excessive nutrients to support the production of food, but is also a recipient of harm where this is not undertaken in a

[872] http://www.nine-esf.org/files/ena_doc/ENA_pdfs/ENA_Tech%20Summary.pdf
[873] https://www.abebooks.co.uk/servlet/BookDetailsPL?bi=5191212013

sustainable way. In this sense soil, while it can act as a vector of nutrient loss to other sensitive receptors, is not the primary cause of these impacts.

10.1.3 Baseline

As explained in annex 8, it is estimated that 67% of Europe's ecosystem area is exposed to excessive nitrogen levels (78% of Nature 2000 areas, 65-75% of agricultural soils), mainly due to fertiliser use in agriculture.

The following table covers the baseline of implemented and planned policies that relate to setting a legally binding target of 50% reduction of nutrient losses at EU level by 2030.

Table 10-1: Relevant policies to the NUT building block

Policy	Relevant Component	Relevance to NUT
Council Directive 91/676/EEC of 12 December 1991	Statutory management requirement (SMR 1)	Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (OJ L 375, 31.12.1991, p. 1)
Common Agricultural Policy (CAP)	CAP Reform (2023-27)	Specific objective 5: Foster sustainable development and efficient management of natural resources such as water, soil and air. Reducing nutrient leakage: Nitrate in groundwater – percentage of groundwater stations with N concentration over 50 mg/l as per Nitrate directive. Groundwater stations exceeding 50mg/l are in breach of the Nitrate Directive.
	CAP Strategic Plans (CAP SPs) (from 2023)	Under CAP reform, strategic plans will be implemented at national level and address the specific needs of that Member States in relation to EU-level objectives these specific objectives should include a focus on nutrient losses where relevant.
	Eco-schemes (from 2023)	Under CAP reform, eco-schemes seek to provide stronger incentives for environmentally friendly agricultural practices (e.g. soil conservation, organic farming, carbon farming etc).
	Agriculture, Environment and Climate Conditions (AECCs)	A funding scheme that farmers can choose to enrol in and will affect soil management practices based on AECC prescriptions, improving soil structure, protecting soils from erosion and reducing fertiliser and pesticide use.
EU Green Deal	Farm to Fork Strategy and EU Biodiversity Strategy	A set of common objectives of nutrient losses by 50% by 2030 while preserving soil fertility.
Nitrates Directive	Establishment of codes of good agricultural practices	In 1991, the EU introduced the Nitrates Directive, which aimed to reduce water pollution caused or induced by nitrate from agricultural sources. The Directive requires Member States to apply agricultural action programme measures throughout their whole territory or within discrete nitrate vulnerable zones (NVZ's). Action programme measures are required to promote best practice in the use and storage of fertiliser and manure by 4 key measures: -Limiting inorganic N fertiliser application to crop requirements.

Policy	Relevant Component	Relevance to NUT
		-Limiting organic manure applications. -Seasonal restrictions on the application of slurry, manure sand sludge on sandy and shallow soils. -Maintenance of farm records that encompass cropping, livestock numbers and fertiliser management.
	Nitrate Vulnerable Zones (NVZs)	MS must identify NVZs and set action plans to control pollution. Action programmes are to be implemented by land managers.
National Emissions Reduction Commitments Directive(NECD)	Annex III, Part 2: Emissions reduction measures	Measures to control ammonia emissions. Member States shall prohibit the use of ammonium carbonate fertilisers and may reduce ammonia emissions from inorganic fertilisers by using the following approaches: (a)replacing urea-based fertilisers by ammonium nitrate-based fertilisers; (b) where urea-based fertilisers continue to be applied, using methods that have been shown to reduce ammonia emissions by at least 30 % compared with the use of the reference method, as specified in the Ammonia Guidance Document; (c) promoting the replacement of inorganic fertilisers by organic fertilisers and, where inorganic fertilisers continue to be applied, spreading them in line with the foreseeable requirements of the receiving crop or grassland with respect to nitrogen and phosphorus, also taking into account the existing nutrient content in the soil and nutrients from other fertilisers.
Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)	Protected areas and surface water status	PROTECTED AREAS - (iv) nutrient-sensitive areas, including areas designated as vulnerable zones under Directive 91/676/EEC and areas designated as sensitive areas under Directive 91/271/EEC; 1. SURFACE WATER STATUS 1.1. Quality elements for the classification of ecological status includes nutrient conditions

10.2 NUT - 1

10.2.1 Description of option and requirements for implementation

Only one option is defined under this building block. The EU would set a legally-binding target of 50% reduction of nutrient losses at EU level by 2030 calling on Member States to define national or regional integrated nutrient management approaches to reduce nutrients losses including tackling hot spots.

It would be left to Member States to define their management approach. That said, it is envisaged that this could involve steps such as: producing nutrient management plans for each soil district, and formulating sustainable measures to reduce nutrient losses from soil. The latter could include improvements to general soil health via sustainable soil management practices (link to SSM building block), but would require measures specific for fertiliser, management/planning, application, manure application and land management.

According to the OPC questionnaire, which asked the question, ‘How would you rank the effectiveness of the following measures in achieving the 50% reduction of nutrient losses by 2030', most survey responses (across all measures an average of 77%) found that either 'legally binding targets at EU level' and 'legally binding targets at national/regional level' would be either reasonable or very effective for achieving the 50% reduction of nutrient losses in 2030. It is notable that the response across the measures mentioned[874] in the survey was positive. Furthermore, it is important to note that the survey question did not distinguish between whether such a target should be implemented explicitly as part of a Soil Health Law or otherwise.

10.2.2 Assessment of impacts

Economic impacts

As explored in the economic impacts associated with SSM and REST, measures to manage nutrients and nutrient loss in soils are likely to carry an upfront (and possible ongoing) cost associated with implementation (***public authority budgets)***. That said, these measures can also deliver economic benefits. By applying sustainable management practices to target and retain nutrients this can reduce input costs and ensure greater uptake of nutrients by the target crop. Land managers will see a benefit in the reduction in nitrate inputs for example, nitrogen fertilisers. Purchases of fertiliser represent around 6% on average of the share of input costs for EU farmers and up to 12% for arable crops farmers.[875] Recently, there have been a sharp increase in fertiliser prices with the world experiencing a global mineral fertiliser crisis provoked by the high energy prices.[876] From September 2021 to September 2022, there has been a 149% rise in the price of nitrogen fertilisers and compared to previous years the increase is even stronger with it being between 3 to 5 times more expensive than usual for farmers to buy fertilisers. Therefore, by reducing the leaching of nutrients from soil this should have a positive impact on land managers/farmers. The benefits of reduced nitrate inputs from using cover cropping were quantified, the results of which can be found in section 11 (Quantification of economic impacts). Using legumes in grasslands will have cost-savings from reduced use of mineral fertiliser and potentially reduced costs for livestock fodder purchase due to a higher nutrient content. Depending on when the legumes go in, the adjustment costs for farming businesses could be the purchase of legume seed or a potential reduction in income across a crop rotation.

For phosphate reduction, a barrier to uptake of measures to reduce losses is that in the current market, phosphate is less costly to buy new than manage better the circularity of inputs - hence fewer cost neutral management activities are available that can deliver reductions in nutrient loss. Until circular economy/nutrient cycling can improve the cost balance it is difficult to change the market for mineral phosphate. Organic manure is an alternative source but still can be prone to mismanagement and may only be relevant where there are local sources of organic materials (manures and digestates/compost). Better distribution would help, but is challenging from an infrastructure and cost perspective.

Implementing this option would also carry an ***administrative burden***. Member States could face high one-off costs (EUR 13.5m, including one consultant study) and moderate

[874] Measures included; advisory services for farmers, recommendations to MS on nutrient management, action plan at EU level, national/regional actions plans, legally binding fertilization rates for the main crops, adapted to regional pedo-climatic conditions, legally binding targets at EU level, legally binding targets at national/regional level and continue funding research and innovation actions to address safe and environmentally sound solutions.

[875] https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_6566

[876] https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_6566

ongoing costs (1 FTE or EUR 1.35m) for developing a management plan, consulting with stakeholders and the EC on the nutrient load reductions needed to achieve these goals, as well as gaining support from external specialised consultants to assist with the development of the Action Plan. This could also involve the development of nutrient budgets where these are implemented to assist management (as in Denmark). In each Member State, this impact will vary according to the current nutrient losses and nutrient management approaches. The EC would also incur a medium level of upfront administrative burden to determine the baseline level of nutrient losses in each Member State (EUR 242,000). Illustrative total estimates are presented in the table below.

Table 10-2: Administrative burdens associated with NUT

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-off costs	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
NUT	16,000	24,000	910,000	1,400,000	-	-	920,000	1,400,000

Note: upfront costs have been annualised over a 20 year period using a discount rate of 3%, as guided in the BR Toolbox

In 2021, the EU imported around 26 million tonnes of nitrogen fertilisers, nitrogen and phosphate intermediates. The imports represent respectively 30%, 68% and 85% of the EU consumption of nitrogen, phosphorus and potassium fertilisers. This dependence on imports exposes EU farmers and the European fertiliser sector. Therefore, by reducing nutrient losses this should reduce the EU's dependence on imports and the negative impacts associated with the market fluctuations in fertiliser prices (***trade and competitiveness impacts)***.

Environmental impacts

A reduction in nutrient losses will have a positive impact on ***water quality,*** by improving surface and groundwater quality, thereby lowering risks to human health and biodiversity. In the Jutland region in Denmark, water quality improved by 25% after starting an efficient control of manure and silage stores.[877]

Reducing the amount of nutrient losses will have a significant positive impact on ***biodiversity***. For example, increased nutrient fertilisers in waterbodies can cause excessive plant and algal blooms as well as hypoxia (refers to a reduced level of oxygen in the water). Harmful algal blooms can produce toxic or harmful effects on people, fish, shellfish, marine mammals and birds whereas hypoxia causes marine life to die or if mobile leave the area. Using sustainable soil management practices for example using organic fertilisers effectively including compost from bio-waste recycling[878] will reduce the risk of nutrient loss through improved nutrient cycling and soil health. Compost is also beneficial as it is a type of nutrient reuse, therefore reducing the need for raw nutrient materials which need to be produced.

[877] https://www.frontiersin.org/articles/10.3389/frsus.2021.658231/full
[878] https://www.compostnetwork.info/ecn-response-on-roadmap/

Improved soil structure and nitrogen planning can reduce nitrous oxide (***climate change)*** by avoiding the conditions that cause nitrogen losses. Nitrous oxide is approximately 300 times as potent as carbon dioxide at heating the atmosphere and according to the latest IPCC report[879] agriculture accounts for 16 to 27% of human-caused climate-warming emissions due to nitrous oxide emissions. The production of nitrous oxide from soil is a natural, biological process. In healthy soils with a high oxygen content, bacteria produce nitrate from ammonium in a process called nitrification which can also create nitrous oxide. When there is an absence of oxygen a different process called denitrification occurs where bacteria in the soil reduce nitrates to gaseous nitrogen. Denitrification is more likely in wet or compacted soil. Both processes have the same result: the production of nitrous oxide, although larger amounts result from denitrification. When nitrogen is added to the soil, these bacteria then produce nitrous oxide. The application of nitrogen fertilisers to land is widely accepted to be the key driver for agricultural nitrous oxide emissions.[880]

The measures implemented to reduce nutrient losses may also have a range of complementary environmental benefits. For example, using legumes in grasslands has many environmental benefits including; improved soil fertility and nutrients available for the plant through N-fixation, increased carbon sequestration and storage in the soil, less acidification due to reduced fertilisation, reduced nitrous oxide and carbon dioxide emissions through less fertiliser production and use. A potential drawback of using legume-risk swards is there is the risk of nitrate leaching and increased nitrous oxide emissions after ploughing compared to using inorganic fertiliser. The increased risk comes from the increase in the availability of soil mineral nitrogen.[881] However, if the additional nitrogen is used by the following crop then it is not necessarily any worse in terms of nitrogen loss of using inorganic fertilisers. The use of legumes is good for livestock productivity because legumes are high in energy and protein as well as for arable systems in terms of improving yield productivity through improved soil health.

A reduction in nutrient loss will also reduce the amount of phosphorus extracted as a raw material (***raw material savings)***. Phosphorus is made from phosphate rock, which is a non-renewable resource that will start to run out in the next few decades. Processing the rocks produces carbon emissions, radio-active-by-products and heavy metal pollutants.

Social impacts

Nitrogen pollution can have impacts on ***human health***, with the fallout estimated to cost each person in Europe up to £650 every year[882] (EUR 756.14).[883] Children are vulnerable to a nitrogen-based compound called nitrates in drinking water. Excess nitrogen in the atmosphere can also produce pollutants such as ammonia, ozone and particulate matter ($PM_{2.5}$) which can impair ability to breathe, limit visibility and alter plant growth.

10.2.3 Distribution of effects

Land mangers/farmers will be impacted by these measures as they will need to implement sustainable soil management practices to reduce nutrients losses. Although it

[879] https://www.ipcc.ch/srccl/chapter/summary-for-policymakers/
[880] https://www.cla.org.uk/news/reducing-emissions-in-agriculture-nitrous-oxide/#:~:text=The%20production%20of%20nitrous%20oxide,different%20process%20called%20denitrification%20occurs.
[881] https://onlinelibrary.wiley.com/doi/epdf/10.1111/gfs.12496
[882] https://www.rspb.org.uk/our-work/policy-insight/england-westminster/farming-and-land-use/land-use-and-nature/fertilisers/
[883] Using the Bank of England's Annual average spot exchange rate in 2021 (1.1633)

will take time to develop an integrated nutrient management plan and also time and money to invest in different management practices there will also be significant benefits which include increased yields and a reduction in fertiliser costs and more resilient systems. Moreover, land managers may benefit from switching to using organic sources of nutrients rather than purchasing fertilisers due to the sharp increases in prices observed recently. Furthermore, it is uncertain where the adjustment costs will fall as this will depend on the method of implementation by the Member State – in the first instance, the obligation to achieve the nutrient loss target is placed on Member States.

Measures to deliver a nutrients target are likely to predominantly impact rural areas. Although some measures will be delivered in urban areas, the measures will predominantly impact agricultural and forestry land – this represents a greater land area (around 80% of the EU's land area) where nutrients are applied in greater amounts. As a consequence, the costs of implementing these measures will also fall more so on rural areas, but also the majority of the benefits of implementing these measures would also fall to rural areas (e.g. productivity improvements through increase in yield or input cost savings).

As well as farmers, fertiliser producers will be impacted as there will be a reduction in the demand due to a reduction in nutrient losses. Although there is limited diversification, fertiliser producers may have the potential to diversify into more sustainable sources of fertiliser, this may include "Green Nitrogen", processing organic sources from food, plant and agricultural wastes and to add value through improved nutrient technologies which support reductions in nutrient losses.

10.2.4 Risks for implementation

A key risk and potential barrier to the effectiveness of a nutrients target as part of the Soil Health Law is the interaction with actions around nutrients and nutrient loss under other legislation – both in terms of adding to the complexity of the policy landscape, but also regarding whether the Soil Health Law would be the most appropriate location for a legally binding target, which could then effectively influence the various drivers and sources of nutrient loss as a problem.

As defined in the baseline section above, there are lots of links with existing Directives and legislation in terms of reducing nutrient losses. Some key examples of these include;

- ***Nitrates*** Directive – In 1991, the EU introduced the Nitrates Directive, which aimed to reduce water pollution caused or induced by nitrate from agricultural sources. The Directive requires Member States to apply agricultural action programme measures throughout their whole territory or within discrete nitrate vulnerable zones (NVZ's). Action programme measures are required to promote best practice in the use and storage of fertiliser and manure by 4 key measures: Limiting inorganic N fertiliser application to crop requirements; Limiting organic manure applications; Seasonal restrictions on the application of slurry, manure sand sludge on sandy and shallow soils; and Maintenance of farm records that encompass cropping, livestock numbers and fertiliser management.

- According, to a European Environment Agency report published in 2020[884] implementation of the Directive across Europe has been poor, although in the synthesis of Member States' reports for 2000 it concludes that 'Member States have in the last years shown a real willingness to improve implementation'.
- ***CAP strategic plans*** – all Member States addressed the nutrient use efficiency in their CAP strategic plans. The Commission works with Member States to ensure that relevant interventions such as nutrient management plans, soil health improvement, precision farming, organic farming and agro-ecology, higher use of leguminous crops in crop rotation schemes, etc. are widely adopted by farmers. The Commission will invite, when needed, Member States to look into further prioritisation and increasing ambition of such interventions in future revisions of their CAP strategic plans.
- ***Fertilising Products Regulation***[885] ensures better access in the market to fertilisers made from recovered waste and green and circular alternatives to natural gas.
- ***Water Framework Directive***[886] (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) ensures that quality of water is protected by having measures that include for example: Areas that are nutrient-sensitive areas are protected; Rivers, lakes and transitional waters have the correct nutrient conditions; Core parameters including oxygen content, pH value, conductivity, nitrate and ammonium are all monitored in selected groundwater bodies.
- Under the ***National Emission reductions Commitments Directive***[887] (Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC), one of the reduction commitments is a decrease in ammonia emissions. Improved management of nitrogen fertilisers can significantly reduce the loss of nitrogen particularly from urea based inorganic fertilisers and manures.
- From the legislation above, it is clear that there are multiple policies and measures aimed at taking action around nutrient losses. Each are focused on one or more nutrients of reactive nitrogen forms derived from fertilisers. These aim both to encourage the uptake of practices which reduce nutrient losses in key sources (e.g. Nitrates Directive and CAP for agricultural soils ,and the NECD more indirectly), and also aim to monitor and drive a holistic planning approach in the medium where most harm is felt – i.e. water (through the Water Framework Directive).

Furthermore, as noted soil has an important role to play in the nutrient cycle. Soil has nutrients applied to it in agriculture, and how soil is managed can have an influence on the quantity of nutrients lost. However, not all sources and drivers of the problems associated with nutrient loss interact directly with soil – e.g. non-agricultural property development and the management of P in wastewater is a key part of the nutrient story. Also, nutrient loss is not strictly a problem of soil health – as defined in the soil health

[884]https://www.eea.europa.eu/archived/archived-content-water-topic/water-pollution/prevention-strategies/nitrate-directive#:~:text=In%201991%2C%20the%20EU%20introduced,nitrate%20vulnerable%20zones%20(NVZ%27s).
[885] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32019R1009
[886] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060
[887] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.344.01.0001.01.ENG&toc=OJ:L:2016:344:TOC

descriptors, soil health depends on achieving and maintaining nutrient content in a given range, rather than limiting loss strictly.

Hence a key risk associated with this measure it that it will add further complexity to the policy landscape, whereas it is questionable as to whether a nutrient loss target as part of a Soil Health Law would be the most applicable place to be able to effectively tackle all drivers and sources of the problems associated with nutrient loss. Management of soils can form part of the measures to meet the requirements of the wide ranging legislation, however it should be seen as a facilitator alongside technological advancements, reductions in use, improvements in plant and animal science and improvements in practice. Many of these enhancements may involve sustainable soil management practices but many are not relevant to the soil ecosystem. Therefore setting targets within the Soil Health Law may result in an ineffective management of all sources and could limit the implementation of all relevant actions.

In the call for evidence, although 47 out of 71 business associations and business organisations strongly supported the SHL, one of the critiques was against the nutrient reduction target with business stakeholders stating it was not achievable.

10.2.5 Links/Synergies

Monitoring of soils to support nutrient management planning is critical in ensuring balance and effective nutrient applications – hence there is a key link to the MON building block. Soil testing to support nutrient management is common practice but acting upon the testing is critical to drive improvements in plant uptake and consequent reductions in loss of nutrients. Balanced nutrition needs to account for all major macro and micro nutrients as well as soil pH. Often the implementation of a coherent and nutrient management plan to identify and reduce the risks of nutrient loss are not fully developed and the benefits of soil analysis therefore are under recognised.

As noted above, some of the practices defined as SSM will have an impact on nutrients losses. As such, the measures implemented under SSM will have a strong interaction with NUT as they will likely form a key part of any nutrient management plan, in addition to any other actions Member States would need to take to limit nutrient losses.

10.2.6 Summary

Soil nitrogen transformations are the drivers of plant growth and are fundamental to healthy ecosystems. By preventing nutrient losses this should have a positive impact on soil health by partly ensuring that the correct amount of nutrients are available and kept in the soil. To reach the target of reduced nutrient losses, land managers will need to employ sustainable management practises which will not only reduce nutrient losses but also improve the biodiversity of the soil. However, this isn’t the complete story, due to intensive agriculture many soils in the EU have had excess nutrient applications added to the soil. Therefore, to restore soil health it is important to also look at the amount of nutrient that is added as well as the amount that is lost.

Setting a target of nutrient reductions should increase the amount of information and data as well as common governance. However, there are already multiple drivers that try to tackle the nutrients issue, therefore there is potential that this will increase complexity and cause confusion when reporting information. Also soil is not the cause of nutrient losses, it is how it is managed and the application of fertilisers that are the issues therefore a nutrient loss target may not be best placed as part of a Soil Health Law. Both create significant risks to implementation. Furthermore, some stakeholders have questioned whether a legally mandated target is achievable.

There will be an administrative burden and adjustment costs to employ the sustainable management and other practices that tackle the reduction in nutrient losses. However, the benefits of reduced fertiliser use and potentially increased yield should help to overcome the costs. The reduction in the demand for fertiliser use will impact on fertiliser producers.

Table 10-3: Overview of impacts of add-on for a nutrient target

Effectiveness	**Impact on soil health**	+	Practices implemented to tackle nutrient loss in some cases will improve soil health – but nutrient loss is not strictly a problem of soil health (hence smaller benefit anticipated)
	Information, data and common governance on soil health and management	+	Defining the target in law will provide a small improvement in the governance arrangements around soil health and management
	Transition to sustainable soil management and restoration	++	Reducing nutrient loss will deliver a range of positive environmental benefits – in particular surface and groundwater quality.
Efficiency	**Benefits**	++	Transition to SSM key benefit.
	Adjustment costs	--	Measures to manage nutrients and nutrient loss in soils are likely to carry an upfront (and possible ongoing) cost (lower than SSM and REST given more limited scope).
	Administrative burden	--	Moderate ongoing burden for Member States (between EUR 1m and 5m pa) for reviewing and updating management plan (and supporting actions)
	Distribution of costs and benefits	-	Uncertain where costs will fall, but land mangers/farmers will have an important role to play, and would not stand to capture all benefits from practices.
Coherence		+/-	Overlap in the costs and benefits of achieving a nutrient target with those explored under the SSM and REST. Also complementary link to MON. But nutrient loss linked to many existing policies, hence risk around ensuring coherence.
Risks for implementation		---	Uncertain that a nutrient loss target as part of a Soil Health Law would be the most applicable place to be able to effectively tackle all drivers and sources of the problems associated with nutrient loss.

11 CALCULATION OF ADMINISTRATIVE BURDENS

11.1 Methodology

Compliance with the options could create a range of costs for a number of different actors. One such cost are administrative burdens. To assess the potential administrative burden placed on different actors, the EU's Better Regulation Toolbox Standard Cost Model (SCM) (European Commission, n.d.) was used. To estimate administrative costs, the SCM follows a simple equation, combining: number of activities required, with the time required per activity and the cost per unit of time spent. An important component is to determine what actions and activities would be part of the baseline (i.e. in the absence of new options) and which actions and activities are additional, or would be reduced, as a result of a new policy option. Separating the costs of the existing activities (the baseline scenario), from the estimated additional costs or cost reductions of new policy options was critical to determine the incremental costs arising as a result of the implementation of new options.

This section provides a brief overview and analysis of the administrative burden each of the options under the five core building blocks and four add-ons would imply for relevant stakeholders, namely the European Commission and the Member States. No significant additional administrative burdens are anticipated as a consequence of the interventions is expected for other actors – i.e. businesses and citizens.

The assessment of these costs was formed considering several relevant sources, in particular the analysis of stakeholder engagement responses. As gaps were identified, experts were consulted to fill in those missing pieces of information and to complement the existing data. Based on the latest scientific knowledge, expert judgement was also essential for sense-checking and adjusting estimations made in previous assessments and reports. On this basis, an illustrative quantitative estimate of costs was developed for all options, both in terms of one-off costs and/or annual recurring costs.

Interventions were assigned a qualitative rating based on cost ranges from low (< EUR 1m) to high (>EUR 5m). This section also considered the potential for burden savings, but no savings were identified in the case of the options considered here. The 'key table' below presents the assessment criteria which is reflected throughout each of the interventions. These ranges apply to operational costs per annum, and annualised capital costs.

Table 11-1: Administrative burden Key

Impact	Range (EUR)
Very low cost	(-)
Low Cost	< 1m
Mid Cost	1m – 5m
High Cost	> 5m

It is important to caveat that the illustrative quantitative estimates in some cases are based on very limited, if any, underpinning evidence and data. As such, some estimates rely more so on expert judgement. As such, the costs in practice could vary relative to the ranges presented here. In addition, alongside the cost per action, assumptions have been made around the quantity of 'actions' that are required – e.g. the number of plans to be made or revised, the number of new monitoring sites required, etc. Again the quantity of 'actions' could vary in practice, and as such the costs may scale up or indeed down where more or fewer of such actions are required in practice.

11.2 Monitoring administrative cost calculations

11.2.1 Introduction

Monitoring of soil health is a critical activity to understand the health of soils across the EU, and to determine the subsequent activities required to achieve good health. The options under the monitoring (MON) building block aim to improve monitoring of the status of soil across the EU, and subsequently the effectiveness of the measures taken towards achieving healthy soils.

Although some Member States have made progress in monitoring the status of soil health, the methodology is often inconsistent. Differences are commonly found regarding the chosen soil health indicators, sampling size and frequency, and measurement methods. The lack of harmonisation between approaches hampers land degradation assessments, environmental impact studies and adapted sustainable land management interventions.

The additional administrative burden associated with the options under MON, and the requirements to go further in terms of monitoring, will be a key associated impact. Given the likely importance and significance of the additional monitoring costs, this section sets out evidence collected around the costs of monitoring, and the approach taken to produce an illustrative estimate of the additional burdens associated with the options under the MON building block.

11.2.2 Baseline

The first step in calculating additional monitoring costs was to establish a baseline of current soil health monitoring in each Member State. The following sources were reviewed to determine whether in each Member State at least one soil health study had been conducted to explore one or more soil health descriptors on the 'minimum list'. The monitoring cost for 'land taken and imperviousness area' was not considered in this analysis as these were explored separately as part of the LATA add-on. Likewise costs for testing contamination status of soils were not considered as these were explored separately as part of the DEF building block 4. The cost of mapping soil erosion was also left out of the analysis as assessing and mapping erosion is a challenging task which requires the evaluation of major soil degradation processes such as water erosion, wind erosion, soil acidification, soil compaction, loss of organic matter and heavy metal intoxication.[888]

A report by EJP Soil in 2021[889] on harmonised procedures for creation of soil databases and maps was reviewed to determine in each Member State the baseline for:

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[888] Panagos, P; Katsoyiannis, A (2019), Soil erosion modelling: The new challenges as the result of policy developments in Europe. Available at: https://www.sciencedirect.com/science/article/pii/S0013935119301264

[889] EJP Soil (2021), Towards climate-smart sustainable management of agricultural soils: Report on harmonized procedures for creation of databases and maps, Available at: https://ejpsoil.eu/fileadmin/projects/ejpsoil/WP6/EJP_SOIL_D6.1_Report_on_harmonized_procedures_for_creation_of_databases_and_maps__final.pdf

- Acidification- pH (all soils),
- Topsoil compaction- Bulk density in topsoil (all uses),
- Subsoil compaction- Bulk density in subsoil (all uses),
- Loss of soil capacity for water retention- soil water holding capacity (all uses),
- Loss of carbon- Soil Organic Carbon (SOC) (all uses except forests),
- Salinisation- Electrical Conductivity dS/m (measurement only in dry and coastal areas).
- This information also provided for each Member State sampling programme: Number of soil sampling sites, most recent reporting year, and frequency of sampling (years between campaigns). Stakeholder engagement responses from Member States were also reviewed to determine the baseline for:
- Excess nutrients: phosphorous- Extractable phosphorus in mg/kg (all uses),
- Excess nutrients: nitrogen- Nitrogen in soil (all uses),
- Soil biodiversity loss- potential soil basal respiration, or alternative soil biodiversity indicators to be defined by Member States such as: Metabarcoding of bacteria and fungi and animals; Abundance and diversity of nematodes; Microbial biomass (all uses); Abundance and diversity of earthworms (in cropland).

Data on the number of LUCAS 2022 soil sample sites (41,004 soil sampling sites total EU-27, also disaggregation by Member State) was provided by the JRC.

11.2.3 Additional costs at existing sampling sites

Error! Reference source not found. below describes the number of sampling points (sampled every five years), year of last soil campaign,[890] and uses ‘Y’ for yes and ‘N’ for no, to describe whether each Member State had already conducted similar soil monitoring tests for the soil indicators proposed[891] (i.e. is any data provided for each individual Member State against a given descriptor). Some Member States currently have extensive soil sampling. If there was no data available to suggest either yes or no, it is assumed that the Member State has not included that descriptor in any of their soil health studies (as denoted by ‘-‘ in the table below). Some Member States have at least some data (i.e. from one sampling site) on all the soil health indicators. However not all soil sampling sites in each Member State are monitoring all descriptors denoted as ‘Y’ in the table below. It is not known (due to insufficient data being available) for all Member State how many descriptors are measured at how many sampling points, and hence also whether a sufficiently representative sample for a given descriptor is being collected across existing sites. As a working assumption, estimates assume that if there is soil health indicator data, it is available, it has been monitored at a sufficient number of sites. Hence Member States would only incur additional costs from existing sites where no data is collected across sites for a specific descriptor (i.e. there is an ‘N’ against a descriptor in the table below). This will lead to a slight underestimation of the total costs associated with achieving a comprehensive monitoring network – in some cases where data is

[890] EJP Soil (2021), Towards climate-smart sustainable management of agricultural soils: Proposal of methodological development for the LUCAS programme in accordance with national monitoring programmes,
Available at: https://ejpsoil.eu/fileadmin/projects/ejpsoil/WP6/EJP_SOIL_Deliverable_6.3_Dec_2021_final.pdf

[891] EJP Soil (2021), Towards climate-smart sustainable management of agricultural soils: Report on harmonized procedures for creation of databases and maps,
Available at: https://ejpsoil.eu/fileadmin/projects/ejpsoil/WP6/EJP_SOIL_D6.1_Report_on_harmonized_procedures_for_creation_of_databases_and_maps__final.pdf

available for a given descriptor in a given Member State, the sample may not be sufficiently representative, and a Member State may still need to increase its sampling efforts (and costs) for the given descriptor. That said, the costs of increased testing at existing sites are likely to be significantly less than the costs of adding new sites, and the costs not captured are not anticipated to lead to a significant change in the order-of-magnitude or relative differences assessed between the options.

Table 11-2: Baseline number of sampling sites and coverage of soil health indicators in soil health studies across each Member State

Member State	# of MS sampling points	*Equivalent # of MS sampling points every 5 years*	Year of last MS soil campaign	# of LUCAS 2022 sampling points	pH	Bulk density in soil	Available water capacity	SOC	Electrical Conductivity	Extractable phosphorus	Nitrogen in soil	Heavy metals	Biological
Austria	2,000	1,000	2020	1,512	Y	Y	Y	Y	Y	Y	Y	Y	-
Belgium	3,125	1,563	2021	1,158	Y	Y	N	Y	Y	-	N	N	-
Bulgaria	0	0	-	1,356	Y	Y	Y	-	Y	Y	Y	-	-
Croatia	0	0	-	290	-	-	-	-	-	-	-	-	-
Republic of Cyprus	0	0	-	1,414	-	-	-	-	-	-	-	-	-
Czech Republic	214	178	2019	2,845	Y	Y	N	-	Y	-	Y	N	-
Denmark	450	563	2020	1,348	Y	Y	N	-	-	-	Y	Y	-
Estonia	30	30	2021	461	N	Y	N	Y	Y	Y	Y	Y	Y
Finland	630	315	2018	1,605	Y	Y	Y	Y	-	Y	Y	N	-
France	2,241	679	2016-2027	4,362	Y	Y	Y	-	-	-	Y	Y	Y
Germany	3,904	3,904	2022	1,818	Y	Y	Y	-	Y	Y	Y	Y	-
Greece	0	0	-	4,776	-	-	-	-	-	-	-	-	-
Hungary	1,230	683	2021	607	Y	Y	N	-	-	-	Y	Y	-
Ireland	800	400	2015	911	Y	Y	Y	Y	Y	-	Y	N	Y
Italy	26	130	2022	740	Y	Y	Y	-	Y	Y	Y	N	-
Latvia	95	95	2022	2,579	Y	Y	Y	Y	Y	-	Y	N	Y
Lithuania	10,000	5,000	2020	1,110	Y	Y	N	Y	Y	-	Y	Y	-
Luxembourg	0	0	-	201	Y	Y	-	-	-	-	-	-	-
Malta	0	0	-	717	Y	Y	Y	-	-	Y	Y	Y	-
Netherlands	1,392	696	2018	20	Y	Y	N	Y	Y	-	Y	Y	Y
Poland	216	216	2020	895	Y	Y	Y	-	-	-	Y	Y	-
Portugal	652	652	2008	3,230	Y	Y	Y	Y	Y	Y	Y	Y	-
Romania	0	0	-	998	Y	Y	Y	Y	Y	Y	Y	Y	Y
Slovakia	451	451	2022	1,614	Y	Y	Y	Y	-	-	Y	N	-
Slovenia	2,000	2,000	2015	2,845	Y	Y	N	-	-	Y	N	N	-
Spain	4,006	4,006	2021	512	Y	Y	Y	-	-	Y	Y	Y	Y
Sweden	2,000	1,000	2021	1,080	Y	Y	N	-	-	-	Y	N	-
Total*	35,462	*23,561*	-	41,004	23	24	14	11	13	11	21	13	7

**Totals for each of the soil health descriptors are equal to the number of Member States that have evaluated each descriptor in their soil health study.*

11.2.4 Additional number of new soil sampling sites

JRC has produced a geostatistical-determined sample grid for DG ENV that would be able to assess soil health against all criteria on the minimum list with an error of 5% at EU level. This suggests that a network of 216,000 soil samples is required to monitor with this level of error. Hence, this is the number of total sampling sites required under the MON comment elements. The number of additional sites this implies over and above existing sites in the baseline was estimated by scaling up soil surveys across the EU.

The number of additional sampling sites that will be implemented under MON Options at this stage is uncertain. This will depend on how each option would be implemented by Member States at a national level, and the programme of sampling that they would put in place to monitor against the descriptors on the minimum list.

The development and adoption of transfer functions to LUCAS under Options 3 and 4 allows the data collected through the new and existing Member State sites to be compared and combined with data from LUCAS sites. It is assumed that LUCAS sampling frequency aligns with the requirement to sample and report every 5 years under the options (historically LUCAS has sampled on a slightly more frequent basis of 3-4 years). As such, fewer additional new sites would be required to achieve a total sampling grid of around 216,000 sites - the combined total of Member State and LUCAS soil sampling sites (around 64,000 soil sampling sites).

Currently different Member State sampling programmes occur with different frequencies. Where Member States currently monitor on a five yearly basis or less, the current number of sampling points has been adopted in the baseline, hence reducing the additional monitoring costs of different Member States under the options. In this case (aside from the potential additional costs to achieve complete coverage of all indicators at existing sites), these existing sites can be combined with sampling at new monitoring sites. However, where Member States currently sample less frequently than every five years, an increase in sampling frequency would be required at existing sites, hence also incurring an additional cost. In this case, an allowance has been made to include the additional costs of increasing frequency at existing sites.

Under Option 2, Member States are simply obligated to use transfer functions where these exist in science. As such, for many descriptors, transfer functions will not exist. In these cases, sampling data from new or existing Member State sites cannot be compared with or combined with LUCAS data points. As such, to monitor against all descriptors to a sufficient level of robustness, Member States would need to adopt a greater level of new sampling sites to achieve the overall level of 216,000 sites, as LUCAS sites would no longer be counted towards this total. Hence under Option 2, the ideal number of sites is compared to a baseline only considering existing Member State sampling points of around 23,600 (number of existing sites expressed on a basis equivalent to a 5-year sampling frequency – total true number of sampling sites is around 35,000, but some are sampled on a basis less frequent than every 5 years).

11.2.5 Cost estimates of soil monitoring

Summarising the above, Member States may incur additional monitoring costs:

- To ensure a complete coverage of the minimum list of descriptors at existing sites
- To ensure the required 5-year frequency of monitoring at existing sites
- To introduce new sampling sites to achieve the required coverage to assess soil health descriptors to a sufficient level of robustness.

The assumed costs for testing were based on evidence provided by stakeholders which is presented in the table below. The average of the cost data below was considered in estimations as they provided the most granularity in terms of testing, labour and materials costs.

Table 11-3: Range of standard soil monitoring costs

	Cost Min	Cost Max
Labour: preparations, site visit, sampling, sample management and administration*	100	100 (EUR 100 assumed to be average wage 1 days' work for soil tester)
Materials: transport costs, equipment, consumables, energy, etc*	150	150
Chemical analysis set: Examples: pH, SOC, carbonates, total N & K, available P, cation exchange capacity, selected heavy metals **	30	30
Physical analysis set: Examples: moisture, texture, density, hydrology, aggregate stability*	150	300
Biological analysis set: Examples: eDNA, microbial biomass and activities, selection of soil animals (abundances, structural diversity)*	150	1000 (Molecular Barcoding Method)

* MS response to targeted stakeholder consultation, **Response to working paper on 'Soil Monitoring and LUCAS'

Detailed costs on soil monitoring parameters from a separate source are presented in the table below. These are not considered in analysis as this did not include labour and materials costs. However, it is useful to acknowledge that this data from a separate source corroborates the cost per sample type from the source presented above which is applied in the analysis.

Table 11-4: Detailed soil monitoring costs by parameter

Problem/soil degradation	Selected soil monitoring parameter(s)	Cost
Soil compaction	Bulk density in soil (all uses)*	23
Soil biodiversity loss	Metabarcoding of bacteria and fungi - Abundance and diversity of nematodes - Microbial biomass (all uses) - Abundance and diversity of earthworms**	51-250
Soil contamination	Heavy metals (all uses)**	30-169

* Geolabs (2022), Bulk & Dry Density Test Rates. Available at: https://geolabs.co.uk/classification/#tab-id-5, ** MS responses to targeted stakeholder consultation and expert feedback

11.2.6 Methodology cost estimates of monitoring at current and additional sites

Costs were calculated both for new additional sites, and also where testing needs to be expanded at existing Member States sites to cover all the descriptors on the minimum list. With respect to existing sites, the additional testing needs were identified on the basis of the current tests carried out by each Member State, as set out in **Error! Reference source not found.**. It is assumed that:

- For chemical, physical and biodiversity analysis tests, Member States only incur cost of the soil health test if not already testing for this.
- Where a gap is identified in the existing testing regime and at least one additional test is required, an additional labour and material cost is included.

All new, additional sampling sites incur a cost of soil health tests for chemical, physical and biological parameters, in addition to labour and material costs.

11.2.7 Results

The results in the table below show that as the soil health descriptors are the same across all options, the cost of soil monitoring varies depending on the number of sampling sites expected. Although Option 3 and 4 will result in a lower number of sampling sites, the associated costs are still significant.

Table 11-5: Number of additional sampling sites and cost by option

	Option 2	Option 3 & 4
Number of additional sampling sites*	195,000	164,000
Total cost (EUR over 5 years)	236m	202m
Annual cost (EUR pa)	47.1m	40.3m

*Assumes that Member States conducting more than the geostatically preferred number of soil samples will not reduce their number of soil sample sites.

11.3 Administrative burden tables

The following tables present the illustrative estimates and underpinning assumptions for the upfront and ongoing administrative burdens associated with the options across building blocks.

11.3.1 SHSD

Table 11-6: Administrative burden of SHSD interventions (Business/Citizen/Other costs are not included in the table as costs are considered to be negligible)

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Comments / assumptions
Define descriptors for soil health	Common	EC to define minimum list of descriptors to define soil health and set these in law.	121,000		135,000		A low one-off cost is expected to be incurred by the EC to develop a proposal for the minimum list of descriptors, produce a guidance document, consult with MS and conduct legal review.
Define soil districts	2	Soil districts to be established entirely by MS without common EU criteria.			4,725,000		"A medium one-off cost is expected to be incurred by MS to define and develop the methodology for establishing soil districts and appoint Soil District Authorities responsible to achieve healthy soils in the district. The magnitude of costs would depend on each MS considering the number of soil districts developed, the complexity of the method and the availability of soil data. MS may resort to a simple method of assigning soil districts using administrative units. Involves the support the support of external specialised consultants for investigations and evidence gathering in each MS and administrative staff in each MS.
Define soil districts	3	Soil districts to be established by MS, following a set of mandatory criteria for its establishment: the whole national land territory must be covered by soil districts; in defining soil districts, Member States should take into account administrative units and seek as much as possible a certain homogeneity. The following parameters should be taken into account: soil type as defined by the World Reference Base for Soil Resources; climatic conditions or environmental zone andland use/land cover class. .) MS will define the method and algorithm to assess the soil district as healthy or not, based on the health status of the soil (as defined in thematic area 'Soil Health') from the samples collected on this soil district.	60,500		5,400,000		A low one-off cost is expected to be incurred by the EC to develop mandatory criteria on homogeneity. Further to this, the EC would have to develop guidance for MS describing the criteria. A medium one-off cost is expected to be incurred by MS to define and develop the methodology for establishing soil districts and appoint Soil District Authorities responsible to achieve healthy soils in the district. The magnitude of costs would depend on each MS considering the number of soil districts developed, the complexity of the method and the availability of soil data. Involves the support the support of external specialised consultants for investigations and evidence gathering in each MS and administrative staff in each MS.
Define soil districts	4	Soil districts to be established entirely by EC, based on a set of criteria on homogeneity bearing upon: maximum share of surface allocated to land uses other than the dominant land use in the soil district; maximum standard deviation in the values taken by the descriptors of the 'minimum list' between samples taken in the soil district (using the sampling procedures defined in the thematic area MON on monitoring) EC define the method and algorithm to assess the soil	863,000		270,000		A medium one-off cost is expected to be incurred by the EC to define and develop the methodology for establishing soil districts and appoint Soil District Authorities responsible to achieve healthy soils in the district. The European Commission may require the preparing, managing and analysing stakeholder events and public consultations to support soil district development. "

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Comments / assumptions
		district as healthy or not, based on the share of the samples collected on this soil district where the soil is assessed as in 'good' health (as defined in thematic area 'Soil Health'). MS to define the threshold bearing on the share of samples, collected in a soil district, indicating a 'good' soil health, for the soil district to be assessed as 'healthy'.					

11.3.2 MON

Table 11-7: Administrative burden of MON interventions (Business/Citizen/Other costs are not included in the table as costs are considered to be negligible)

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Comments / assumptions
Monitoring and reporting requirements	Common	Obligation for MS to monitor in-situ and report on current status of soil health at least every 5 years, with a maximum delay of 2 years from the latest measurement included, for all 'soil districts' and for all soil descriptors of the 'minimum list' (defined in thematic area 'Soil Health'). MSs monitoring in-situ and reporting on the progress to achieve targets (defined in thematic area "Remediation" and "Restoration) every 5 years. Obligation to MSs to filling in monitoring gaps (compared to obligations) latest by 2028.	181,500	24,200		1,350,000	Medium one-off cost are expected for the EC to set up a reporting system for the current status of soil health and low recurring costs for the EC to review every 5 years. A low ongoing cost for MS to collate monitoring data, conduct analysis and report.
Monitoring and reporting requirements	Common	Remote monitoring at EU level of aspects linked with soil health, such as the following parameters: imperviousness, land cover, soil moisture deficit, and to report on it every 3 years with a maximum delay of 2 years since the measurement.	12,100	4,033			Low one-off and recurring costs for the Commission of providing certainty to performing remote monitoring by putting it into a legal basis. Copernicus Global Land Service already covers imperviousness, land cover and moisture deficit which the Commission will make available a link to MS.
LUCAS soil survey	Common	EU to establish a legal basis for LUCAS as the EU oversight system.					Negligible cost
LUCAS soil survey	Common	Provision of mandate on the access to land, use of data and privacy issues for the LUCAS soil survey. This includes: Provision of the legal basis to ensure access to land is granted by land owners.					Negligible cost

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Comments / assumptions
Define sampling methods	2	MS to define the soil health measurement methods every 5 years, based on an indicative set of standards developed by the EC; if not using the indicated methods MS should use the available transfer functions to translate the measured values into values consistent with LUCAS soil methods. MS to define as well other elements of the methodology not described in the indicative set of standards concerning (including as relevant: (time, seasonality, depth, area/grid), for all soil health descriptors in the 'minimum list' (defined in the thematic area Soil Health).	605,000		2,700,000	47,200,000	One-off and recurring cost for MS are expected to be medium for the sampling point/strategy methodology development, training and adoption, depending on how closely their current sampling methods, if at all, match those that are proposed by the EC. The EC will face high administrative burden to develop the indicative set of sampling standards. For chemical, physical and biodiversity analysis tests, where Member States already meet the geostatistcally preferred number of sampling points, they only incur cost of the relevant soil health test if not already testing for all the monitoring parameters. Where they do not meet the mean sampling point, all additional sampling sites incur a cost of testing, labour and material (even if they have already tested for this).
Define sampling methods	3	EU to define the soil health measurement methods in a soil district every 5 years (time, seasonality, depth), for a limited set of soil health descriptors in the 'minimum list' (defined in the thematic area Soil Health, and to be adapted to the 'minimal list' finally selected): SOC, pH, selected heavy metals, biodiversity. Define main features in law, mandate the European Standardisation Organisations to define the technical standard and mandate the usage of the standard in the sampling of soil (analogy with the Harmonised Standards in product policy - GROW). MS to define the soil health measurement methods in a soil district every 5 years (time, seasonality, depth, area/grid), for all other soil health descriptors in the 'minimum list' (defined in the thematic area Soil Health). If MS do not follow the EU list of methodologies they have to ensure transfer functions to LUCAS whenever possible	605,000	60,500	7,155,000	40,300,000	One-off and recurring cost for MSs are expected to be high for the sampling point/strategy methodology development, training and adoption, depending on how closely their current sampling methods, if at all, match those that are proposed. Each MS will also be required to develop LUCAS transfer function if they do not follow the EU list of methodologies. The EC will face high administrative burden to develop the indicative set of sampling standards. For chemical, physical and biodiversity analysis tests, where Member States already meet the geostatistcally preferred number of sampling points, they only incur cost of the relevant soil health test if not already testing for all the monitoring parameters. Where they do not meet the mean sampling point, all additional sampling sites incur a cost of testing, labour and material (even if they have already tested for this).
Define sampling methods	4	EU to define the method for setting the soil health measurement methods in a soil district every 5 years (time, seasonality, depth), for all soil health descriptors in the 'minimum list' (defined in the thematic area Soil Health). Mandatory EU list of methodologies based on LUCAS, and use of transfer functions for MS historical data. Define main features in law, mandate the European Standardisation Organisations to define the technical standard and mandate the usage of the standard in the sampling of soil (analogy with the Harmonised Standards in product policy - GROW), building on the methods developed for the LUCAS soil survey.	847,000	121,000	9,450,000	40,300,000	One-off cost for the EC are expected to be high for the sampling point/strategy methodology development and guidance for MS to reach the set technical standard and the sampling of soil. High one-off and recurring cost for MS having to adapt Standard Operating Procedure (SOP) to meet mandatory methodologies. For chemical, physical and biodiversity analysis tests, where Member States already meet the geostatistcally preferred number of sampling points, they only incur cost of the relevant soil health test if not already testing for all the monitoring parameters. Where they do not meet the mean sampling point, all additional sampling sites incur a cost of testing, labour and material (even if they have already tested for this).

11.3.3 SSM

Table 11-8: Administrative burden of SSM interventions (Business/Citizen/Other costs are not included in the table as costs are considered to be negligible)

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Comments / assumptions
Obligation of sustainable soil management	Common	The SHL provides a common definition of sustainable soil management and includes issues the obligation to use soil sustainably					Negligible cost
Legislation on the sustainable use of soils	2	EC must produce an indicative annex to the Soil Health Law, that contains sustainable soil management principles and practices as guidance for MS (MS can go beyond the list, no elements are mandatory).	371,000	24,200	135,000		A low recurring is expected to be incurred by the EC for updating the indicative annex to Soil Health Law. Member States may need to review and select which measures to apply, but the costs are not expected to be considerate. It is assumed that a consultant study will also be required. Landowners/private entities will be asked to implement SSM, but technically not obligated to collect/report information.
Legislation on the sustainable use of soils	3	EU to indicate sustainable soil management principlesin the SHL MS can go beyond the list.	431,500	24,200	675,000		A medium one-off cost is expected to be incurred by the EC for updating Soil Health Law and legal review. The requirement for one consultant study is also assumed. A low administrative burden is assumed for MS to review and select which measures to apply and adjust to comply with the mandatory common principles
Legislation on the sustainable use of soils	4	EU to indicate sustainable soil management principles in the SHL set, in a more comprehensive legislative annex to the Soil Health Law, to indicate sustainable soil management principles, and practices harmful to soil health.. MS can go beyond the list, but (some/all) elements are mandatory.	863,000	48,400	675,000		A higher medium one-off cost is expected to be incurred by the EC for updating legislative annex to Soil Health Law and legal review. The requirement for one consultant study is also assumed. A low administrative burden is assumed for MS to review and select which measures to apply and adjust to comply with the mandatory measures.
Obligation of sustainable soil management	4	Obligation for MS to ensure that important sustainable practices are applied everywhere, considering the diversity of local conditions.	274,200		70,400,000		Assumption that MS would develop a soil management plan in all soil districts to ensure application of SSM everywhere. Low upfront costs are expected to be incurred by the EC to check if MSs are complying with the measures. A high one-off cost is expected to be incurred by MSs for monitoring, assessment of threats, development of soil maps, tools, development of a soil management plan and guidance documents.

11.3.4 REST

Table 11-9: Administrative burden of Restoration interventions (Business/Citizen/Other costs are not included in the table as costs are considered to be negligible)

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Comments / assumptions
Define restoration obligations	Common	EU to set an obligation of restoration of unhealthy soils, for all Member States, by 2050.					Negligible cost
Define restoration obligations	Common	The obligation of restoration applies to all unhealthy soils.					Negligible cost
Define restoration obligations	Common	The obligation of restoration applies to all unhealthy soils, except soils that are 'naturally unhealthy'.					Negligible cost
Define restoration obligations	Common	The obligation of restoration applies to all unhealthy soils, except soils that are 'naturally unhealthy', 'unhealthy but unrecoverable' or contaminated sites with acceptable risks for human health or the environment.					Negligible cost
Define programmes of measures to reach targets	Common	Member States develop programmes of measures to achieve restoration of unhealthy soils in scope by 2050, and every 5 years thereafter, to report on its attainment of targets and to revise it accordingly if needed.	60,500	74,200	6,750,000	1,350,000	Low one-off cost are expected for the EC to develop the reporting system and review process. Low recurring costs for the EC to review every 5 years. Medium to high one-off cost related to MS adopting programmes of measures depending on the extent the measures are already being implemented in each of the MS. Report attainment of targets and revise accordingly.
Define programmes of measures to reach targets	3	"EU to define common minimum criteria for the content of the programmes of measures: ## list of examples of criteria e.g. - Monitoring and assessment of soil health for all soil districts	371,000	24,200	135,000		A low one-off cost is expected to be incurred by the EC to develop a proposal for range of value for limited set of descriptors in the 'minimum list', produce guidance document, and consult with MS. Some time saving from a list of common criteria are expected, however outweighed by the effort needed to understand the detail and how far the measures could achieve the target
Define programmes of measures to reach targets	4	EU to fully harmonise the content of the programmes of measures This includes stringent and extensive template that needs to be followed (this is more an administrative issue) and list of mandatory restoration practices	431,500	24,200	675,000		A low one-off cost is expected to be incurred by the EC to fully harmonise content of programmes, produce guidance document, and consult with MS. Some time saving from a list of common criteria are expected, however outweighed by the effort needed to understand the detail and how far the measures could achieve the target

11.3.5 NUT

Table 11-10: Administrative burden of NUT interventions (Business/Citizen/Other costs are not included in the table as costs are considered to be negligible)

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Comments / assumptions
Mandatory 50% reduction in nutrient losses	1	EU to set a legally-binding target of 50% reduction of nutrient losses at EU level by 2030 calling on Member States to define national or regional integrated nutrient management approaches to reduce nutrients losses including tackling hot spots.	242,000	24,200	13,500,000	1,350,000	Medium one-off costs to be incurred by the EC to determine the baseline level of nutrient losses in each MS and conduct legal review. Low recurring costs are expected to be incurred by the EC to check if MS are complying with the measures. MS are expected to face high one-off costs for developing the management plan and to consult with stakeholders and the Commission on the nutrient load reductions needed to achieve these goals, as well as support from external specialised consultants to assist with expert knowledge the development of the Action Plan. This impact will vary according to the current nutrient losses and nutrient management approaches in each MS.

11.3.6 DEF

Table 11-11: Other administrative burden of DEF interventions (Costs of identifying and investigating sites are not presented in the table below but are considered as adjustment cost)

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Business and citizens – recurrent costs (EUR pa)	Comments / assumptions
Definition of the contamination status of sites	Common	EU to set the list of contamination statuses of a site, which includes: (1) site requires investigation for potential contamination (potentially contaminated site), (2) site is contaminated, (3) site requires remediation, (4) site with no significant risk of being contaminated.	250,000					A low one-off cost to be incurred for the EC for an external consultant study.
Registration of (potentially) contaminated sites	Common	Administration and communication in view of registration of (potentially) contaminated sites.				6,900,000	9,100,000	Estimated to be 1% of the annual investigation cost.

11.3.7 REM

Table 11-12: Administrative burden of REM interventions

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Business and citizens - One-off costs (EUR)	Business and citizens - Recurrent costs (EUR pa)	Comments / assumptions
Define remediation obligations	Common	EU to define a legally-binding target, for all Member States, that 100% of 'sites deserving remediation' are remediated by 2050.							Negligible cost
Define remediation obligations	2	Member States allowed to define derogations to their remediation obligations by 2050, in the following cases ##list of cases susceptible to justify derogation.			1,350,000	270,000		270,000	Assume medium upfront cost to all MS, in addition to small ongoing cost to define and manage the derogation process. Small ongoing cost to businesses is expected to apply for derogation.
Define remediation programme	3	Member States to define the prioritisation strategy of their remediation programme to reach the target.			1,350,000				Medium upfront costs are expected for MS to define prioritisation strategy.
Define remediation programme	4	EU to define the prioritisation criteria of the remediation programme of Member States to reach the target.	250,000						EC expected to incur upfront cost of an external consultant study.

11.3.8 LATA

Table 11-13: Administrative burden of LATA interventions (Business/Citizen/Other costs are not included in the table as costs are considered to be negligible)

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Comments / assumptions
Land take	1	EU to define what constitutes land take. This includes defining the main features in law, mandate the European Standardisation Organisations to define the technical standard and mandate the usage of the standard when monitoring land take.	313,000		242,000		A low one-off cost is expected to be incurred by the EC to define land take and produce a guidance documentation to support the dissemination of the formulated definition. A low one-off cost is expected for each MS to consult with stakeholders and arrive at consensus for defining 'net land take'.
Land take	2	Obligation placed on Member States to monitor (and report on) progress towards achieving their target to reduce net land take by 2030 and to achieve no net			5,170,000	3,580,000	One-off costs assumed to be similar to those of National Reference Laboratory (NRL) plans (~880 days for each MS). Ongoing costs for reporting are also taken from NRL, where

		land take by 2050, including on: land recycling, land fragmentation, soil sealing, specific land uses and land cover changes (e.g. Commercial, urban, transports, infrastructures, greenhouses), impacts of land take in terms of loss of ES, monetary value of soil, offsite environmental degradation)					assumed 'establish monitoring procedures', of 50 days required by MS. Ongoing costs for monitoring is dependent upon current level of land take monitoring programmes, and foreseen administrative burden.

11.3.9 CERT

Table 11-14: Administrative burden of CERT interventions (Note: *no costs for businesses and citizens as assume measure is implemented alongside DEF, and hence data on contamination across majority of sites will be available already, hence minimising additional testing requirements)

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Business and citizens - One-off costs (EUR)	Business and citizens - Recurrent costs (EUR pa)	Comments / assumptions
Soil health certificate	1	Establishment of certificates providing information on the contamination status of soils on properties, in order for land buyers to be aware of potential issues in the site they intend to purchase.	290,000		50,000,000	7,500,000		-*	Costs are expected to be borne by the EC to provide guidance documentation. High administrative burden is assumed for each MS to establish a certification platform, this includes maintenance cost of IT tool and employing it specialists.
Soil health certificate	2	EU to define the Soil Health Certificate as: (1) delivered by public authorities in each Member State, (2) based on the publicly-available values recorded on the plot of land for the descriptors for minimum soil health targets and on the threshold or range of values for each descriptor to rate soil health status as being 'good' for each soil type, climatic condition and land use.	290,000		50,000,000	7,500,000		33,100,000	Similar assumptions to measure above for EC and MS. In addition, businesses will undertake additional soil health testing as part of the transaction. Assume 40,000 changes of property or of tenant per year in the EU, for farms involved in commercial activity. Of this number, itcan be assumed that ca. 50% will elect to create a Soil Health Certificate, leading to a total number of certificates in the range of 20,000 certificates / year in the EU.

11.3.10 PASS

Table 11-15: Administrative burden of PASS interventions

Measure	Option	Intervention description	EC - One-off costs (EUR)	EC - Recurrent costs (EUR pa)	MS - One-off costs (EUR)	MS - Recurrent costs (EUR pa)	Business and citizens - One-off costs (EUR)	Business and citizens - Recurrent costs (EUR pa)	Comments / assumptions
Passport for excavated soil	1	EU to set an obligation to ensure a proper treatment of excavated soils, and to follow the principles of standstill and of fit and proper use of excavated soils.	500,000	-	1,350,000	1,350,000	-	-	One-off cost is expected to be incurred by the EC to define guidance documentation. Also cost to MS to set up legislative structure and processes to implement and monitor proper treatment
Passport for excavated soil	2	EU to define the technical features of the Digital Soil Passport. Direct obligation at EU level for operators to record the use of excavated soils in a Digital Soil Passport and for Member States to record the use of excavated soils The content of the soil passport is validated by a certified third party.	290,000	-	50,000,000	7,500,000	-	6,060,000	Greater upfront and ongoing costs assumed for Member States as greater level of oversight, recording and reporting of data required. Assume this would require development of an IT system to oversee the implementation – hence costs for Member States assumed similar to those to implement soil health certificate. Additional costs for businesses as content of passport requires third party verification.

12 QUANTIFICATION OF ECONOMIC IMPACTS

12.1 Introduction

This section sets out the methodology and results of bespoke analysis to explore and illustrate the economic impacts of implementing soil sustainable management (SSM) practices in the EU. This analysis supports the assessment of the 'adjustment costs' and economic benefits associated with the SSM and Restoration (REST) building blocks.

The analysis does not cover administrative burden which is presented in a separate section. This analysis is subsequently drawn on in the Assessment sheets exploring the impacts of the options under SSM and REST building blocks (sections and above), and then subsequently referenced in the comparison of options (Section 6 of the main report) and the costs and benefits of the preferred option (Section 7 of the main report).

12.2 Data review and over-arching methodology

12.2.1 Literature review and data availability

An extensive literature review has been undertaken. The review explored the evidence, data and information available which could be used to assess the impacts of SSM practices. In the literature, some evidence and data is available which can be used to quantify the impacts of the options. In particular, for example, there is good evidence of the benefits of SSM practices at farm level, and the JRC have produced a strong body of work around the costs of remediation measures. However, there are a number of limitations and gaps in the evidence base which have prevented a complete assessment of the overall costs and benefits of these options. In particular:

- quantitative data is not available for all measures or practices;
- where information is available, this is often spread across different sources drawing on different primary inputs, increasing the risk of a lack of consistency between sources;
- the impacts of measures or practices will differ strongly by location based on specific parameters – information is often only available from 1 or 2 case studies with specific contexts, and not often available at the scale of whole EU Member States;
- effects will also differ depending on other factors, such as the extent of implementation or the measures with which they are co-implemented – again evidence is only available for a limited set of implementation scenarios.

Hence, there is no one model, set of models or set of evidence which could be used to produce a complete quantitative assessment of the costs and benefits of SSM practices, restoration and remediation measures which may be implemented under the options. Instead, the data available was gathered and illustrative estimates of the costs (and economic benefits) of deploying a sample of 5 widely accepted SSM practices EU-wide were produced. Many simplifying assumptions are made to develop these estimates and as such there will be a wide of uncertainty around the results produced, but it is intended that these provide an order-of-magnitude estimate of the potential costs associated with the options under the SSM and restoration building blocks.

Furthermore, although there is good evidence and a strong consensus around the environmental benefits of such measures, quantitative data which can be used to provide a reliable estimate of the change in environmental benefits associated with implementing a given measure is severely limited for most practices. Where this evidence is available, it is only available for a handful of measures in specific circumstances, with uncertainty around its replicability across the EU. That said, several studies have instead looked at the ‘costs of inaction’ and have provided estimates of the potential impacts should no or limited action around sustainable management and restoration of soils continue. This can provide a useful baseline against which to compare the illustrative costs of SSM and restoration practices.

Leading on from the point above, data and information is not available which can be used to map from the implementation of a given (or a set of) SSM practices, restoration and remediation measures to a defined change in one or more soil health descriptor. As such, it is not possible to show what effect implementing these measures under the Options will have on the achievement of the descriptors, and hence to define a package of practices with associated costs and benefits that would achieve good soil health.

Finally, the impacts of SSM, as well as REM and REST, will have significant overlap as these will both involve similar principles of changing existing soil management with the objective of improving soil health. Data and methods are not available to define precisely the overlap and allocate specific impacts to specific building blocks. Throughout the analysis, care has been taken to highlight where these overlaps occur, and also in the aggregate analysis to focus on the likely combined, overall benefits.

12.2.2 Methodology and selection of SSM practices

Given the state of the underlying evidence base, the analysis does not look specifically at a single Option or Options under these building blocks, but serves to illustrate the order of magnitude of effects that could be expected if the selected SSM practices were implemented as a consequence of any of the Options under these building blocks.

Improving soil health can have large economic benefits. According to a paper by Panagos et al., 2018[892] the total economic loss in agricultural productivity due to severe erosion in the EU alone is around €1,257 million annually (reference year: 2010), which is about 0.43% of the EU's total agriculture sector contribution to GDP (estimated at €292,320 million), and erosion if one of many pressures facing soil and the ecosystem services it provides. Therefore, capturing the economic benefits as well as the costs is an important undertaking.

A wide range of SSM practices exist that are applicable to different climates, soil types and land-uses (see section 9). Furthermore, the type of environmental benefits delivered and soil threat targeted differ by practice, and importantly the costs and benefits of each practice can vary widely depending on the location, means and extent of implementation. Given the state of the underlying evidence base and lack of a single model with which the impacts of multiple SSM practices can be modelled simultaneously, for this impact assessment study a sample of SSM practices have been selected to subject to quantitative

[892] https://onlinelibrary.wiley.com/doi/full/10.1002/ldr.2879

analysis to illustrate the potential costs and economic benefits associated with such measures.

We have selected the sample based on the following guidelines:

- ***Coverage of soil health pressures*** – different SSM practices work towards resolving one or more soil health pressures – e.g. erosion, acidification, salinisation, etc. To produce an illustrative basket of SSMs, practices were selected such that there is at least one which would work towards each of the identified pressures.
- ***Broadly applicable across all soil, climate and land-use types*** – as explored in the SSM Assessment sheet, not all SSM practices will be universally applicable in all cases. Their applicability, feasibility, and the impacts associated with their implementation will depend on the soil, climate and land-use type. Some practices that are highly beneficial in some contexts, may be detrimental in others. Practices which tend to be more widely applicable across the EU were selected.
- ***Economic payback*** – all SSM will carry adjustment costs, either in the form of upfront (capex) or ongoing (opex) costs. That said, many will also carry an economic benefits for the landowner or manager. Again, the economic payback will be driven by a wide range of variables, and the SSM practices will need to be designed appropriately for each district and land-use to ensure economic returns are maximised. Measures for which an economic payback is more likely to illustrate the potential size of such returns relative to the upfront costs were selected, to test and illustrate the circumstances where many of these practices could be beneficial economically, even before the environmental and social benefits of such measures are considered.

The SSM practices assessed quantitively are:

1. Cover crops – the use of cover crops is increasing and has wide spread potential to be used across different climatic regions, soil types. It also covers the main areas of "maintain soil cover", "maximise living roots" and "maximise biodiversity". It has impact on indicators soil structure, compaction, erosion, biodiversity, organic matter and nutrient availability.
2. Reduced tillage – has potentially great economic impacts by saving fuel and labour plus environmental impacts that come with less disturbance. Reduced tillage can have positive impacts on all indicators.
3. Crop rotations – an important one that has the potential to be implemented everywhere. Greater crop diversity will increase biodiversity and reduce the impacts of monoculture.
4. Use of organic manures.
5. Reduced stocking density.

For each SSM practice, publicly available existing literature and data have been used to build a bottom-up quantification of economic costs and the benefits, scaled up to the EU level. As noted, there are many environmental and social benefits associated with undertaking SSM practices, however, this work focuses purely on the economic costs and benefits e.g., impacts on yields, impacts on fertiliser use. The remaining sections of this appendix present the bottom-up, quantitative analysis of the illustrative economic costs and benefits of these measures.

12.3 Cover crops

12.3.1 Introduction

Cover crops are grown primarily for the purpose of 'protecting or improving' between periods of regular crop production and can contribute to sustainable crop production through: increasing soil nutrient and water retention; improving soil structure/quality; and reducing the risk of soil erosion, surface run-off and diffuse pollution, by providing soil cover and by managing weeds or soil-borne pests.[893]

The focus was on winter cover cropping rather than summer cover cropping because according to the JRC paper[894] (that looked at the adoption of cover crops for climate change mitigation in the EU), survey results showed that the most popular species where winter cover crops (ryegrasses, mustards, clovers, vetch, oats, phacelia and rye). To achieve maximum benefits, winter cover crops should be established as soon as possible after the harvest (by early autumn at the latest and destroyed in late winter, no more than 6 weeks before establishing the following spring crop).[895]

It is important to note that cover cropping can also have some detrimental effect which may reduce farm productivity or pose a challenge to implementation, for example: rotational conflicts, increased weed pressure and costs for seed and establishment. In order for benefits to be fully understood, there is a need for the understanding of the impacts that different crops species have on soils and the following crops in the rotation so that farmers can decide on the most appropriate species and management for their rotation.

In this section, the quantification of the costs of cover cropping is presented, and the benefits which include increased yields and reduced nitrogen leaching (and subsequent raw material input savings).

12.3.2 Quantified Costs

Overview

According to a paper which looked at maximising the benefits of cover crop through species selection and crop management,[896] a recent survey of farmers found that cost was cited as one of the main reasons to not grow cover crops. Cover crop establishment and destruction costs includes the need for seed, sprays and cultivations.

Methodology

Using data from an Agriculture and Horticulture Development Board (AHDB) report (Management of Rotations, Soil Structure and Water)[897] which looked at the cost of cover crop seed and total cost of cover crop (including seed) (Table below), calculation of cost for applying cover crops was performed. This report was part of a work package

[893] PR620 Final Project Report.pdf (windows.net)
[894] https://publications.jrc.ec.europa.eu/repository/handle/JRC116730#:~:text=Common%20vetch%20was%20the%20most,after%20sugar%20beet%20or%20potato.
[895] SW6: Winter cover crops - GOV.UK (www.gov.uk)
[896] https://projectblue.blob.core.windows.net/media/Default/Research%20Papers/Cereals%20and%20Oilseed/2020/PR620%20Final%20Project%20Report.pdf
[897] https://projectblue.blob.core.windows.net/media/Default/Research%20Papers/Potatoes/WP1Rotations9114000101GrowerPlatform.pdf

called the Grower Platform.[898] The project aimed to investigate the effects of different rotation types (e.g. length and composition), soil amendments, cover crops and cultivation strategies on key soil metrics and rotational sustainability for a range of soil types used for crop production.

To calculate these costs, the authors surveyed Grower Platform members about the cost of the cover crop seed and the extra operations associated with the planting, managing and defoliating a cover crop. The list of cover crops used were: Ethiopian Mustard, Grass Ley, Phacelia, Spring Barley, Spring Oats, Volunteers & Weeds, White Mustard, Black Oats, Forage Rye, Linseed, Oil Seed Rape, Common vetch, Mustard, Oil Radish and Winter Oats. Some of these are legume cover crops which convert nitrogen gas in the atmosphere into soil nitrogen that plants can use for example, Phacelia. These operations were assumed to be additional to those used to manage the stubbles/residues from the previous crop. The costs of these operations used were values from standard industry sources (Redman, 2019;[899] ABC 2019;[900] NAAC 2019[901]) rather than the grower's own values which is to allow for more accurate estimates. In some cases, seed costs per hectare were very low, due mainly to cover crops that either used volunteer cereal and weeds or farm-saved grain. Volunteer cereals arise from seed shed at or before crop harvest. In barley the whole ear may break off while in wheat individual grains tend to fall from the spikelet.[902] Volunteer cereal, weed and farm-saved grain are all cheaper because they are not an additional cost to the land manager because they will occur naturally or are from a source already purchased by the land manager. The more expensive cover seed tended to be more specialised mixes for Ecological Focus Area (EFA) compliance, or for winter-hardiness in northern regions in the UK.

Table 12-1: Cost of cover crop[903]

	Cost of cover crop seed (EUR/ha)	Total cost of cover crop (including seed) (EUR/ha)
Average	54	262
Lower SE	45	240
Higher SE	62	282

Source: AHDB[904]

Results

In the EU, 23% of soil cover in arable land during winter is left bare.[905] Using this figure and assuming that 23% of soil cover is left bare in winter for different crop types, cost of cover crop for separate crop categories can be calculated.

[898] https://ahdb.org.uk/11140023-ahdb-rotations-research-partnership
[899] REDMAN, G. (2019). The John Nix Pocketbook for Farm Management: 50th Edition.
[900] The Agricultural Budgeting and Costing Book (2019). Agro Business Consultants Ltd, Melton Mowbray, Leicestershire.
[901] NATIONAL ASSOCIATION OF AGRICULTURAL CONTRACTORS (2019). Contracting Charges Guide 19-20. https://fwi-wp-assets-live.s3-eu-west-1.amazonaws.com/sites/1/2019/06/contractorcharges-2019-20.pdf
[902]https://www.gardenorganic.org.uk/weeds/volunteer-cereals#:~:text=Volunteer%20cereals%20can%20be%20a,ongoing%20source%20of%20cereal%20seeds.
[903] Figures converted from £ to EUR using the annual average exchange rate in 2021 published by the Bank of England: https://www.bankofengland.co.uk/boeapps/database/fromshowcolumns.asp?Travel=NIxRSxSUx&FromSeries=1
[904]https://projectblue.blob.core.windows.net/media/Default/Research%20Papers/Potatoes/WP1Rotations9114000101GrowerPlatform.pdf
[905] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_soil_cover#Data_sources

Splitting by crop type, the table below identifies how much cover crop would cost if applied specifically to the main cereal types in Europe, based on 23% of the areas of land used for each crop. The total cost of cover crop (including seed) (EUR/ha) to the area of each main crop categories was applied.

Using the same assumption as before that 23% of soil is left bare over winter, cost to 23% of the amount of land in Europe used for ***potato crop*** (345,000 ha) is applied. This would equate to **EUR 0.09 billion (+/- EUR 0.01 billion) per annum.**

If this cost is applied to all arable bare soil in Europe (22,328,920 ha) this would equate to a total cost of EUR 5.8 billion (EUR +/- 0.49 billion).

Table 12-2: Cost of cover crops from main cereal types in Europe

Main cereal types	1000 ha of cropland planted with specific crop 2022 (except grain maize and corn-cob mix 2021)	Cost EUR per annum applied to 23% of land cover
Common wheat and spelt	Total 21,934.76 23% **5,044.99**	EUR 1.32 billion (+/-0.11 billion)
Grain maize and corn-cob mix	9247.04 23% **2,126.82**	EUR 0.56 billion (+/- 0.05 billion)
Barley	10,383.20 23% **2,388.14**	EUR 0.63 billion (+/- 0.05 million)
Oats	2,385.40 23% **548.64**	EUR 0.14 billion (+/- 0.01 million)
Rye and maslin	1,884.09 23% **433.34**	EUR 0.11 billion (+/- 0.01 billion)
Total main cereal types	45,834.49 23% **10,541.93**	**EUR 2.76 billion (+/- 0.23 billion)**

12.3.3 Quantified Benefits

Increased yields

According to a study by JRC which looked at the scientific evidence around the impacts of nature restoration actions on food productivity they found evidence that showed that arable farmland (in California and in the Mediterranean region) showed that food crop yield was 16% higher with legume cover crops and 7% lower with non-legumes, compared to plots without cover crops.[906] Another study that was quoted showed that by replacing fallow with legume cover crops led to a mean increase in yield of 25%. A separate meta-analysis of fruit yields showed 9% yield and 7% fruit weight increase with legume cover crops.[907] Using this evidence, quantification of the yield benefits is possible.

[906]https://publications.jrc.ec.europa.eu/repository/handle/JRC129725#:~:text=Although%20we%20cannot%20extract%20a,context%2D%20and%20species%2Ddependant.

[907]https://www.tandfonline.com/doi/abs/10.1080/03650340.2021.1937607?journalCode=gags20#:~:text=Total%20effects%20of%20ground%20cover,Figure%202%2C%20Table%20S1).

Main cereal yields in Europe

Using the study mentioned earlier,[908] it is assumed that crop yields could increase by 16% using legume cover crops. Using data from Eurostat[909] cropland made up a total of 99,850,800 hectares in the EU which equates to 24.2% of the total area.[910]

Production data for the main cereals in production in the EU (common wheat and spelt, grain maize and corn-cob-mix, barley, oats, rye and maslin[911]) is available from Eurostat. As well as production data, Eurostat also publishes selling prices of crop products (absolute prices) for the main crop categories.[912] The crop grouping for prices do not align exactly with the production data grouping, therefore for common wheat and spelt prices for soft wheat and durum wheat were used. Also for rye and winter cereal mixtures (maslin) rye prices were used and for grain maize and corn-cob-mix – maize prices. The price was converted into 2021 prices using the Harmonised Index Consumer Prices[913] and to remove some of the fluctuations in the data – a five-year average of the prices were used.

For each of the crops it was assumed that they would see a high-bound 16% increase when using legume cover crops on 23% of the land cover that is left bare. However, an increase in 16% in yield is a strong assumption because the percentage increase will vary by crop, soil type, climate condition and location. To apply this 16% increase, data from Eurostat was used which shows the amount produced in tonnes per hectare for each main cereal type[914] and then applied the 16% increase to 23% of the area of each main cereal type.

We then multiplied this by the 5-year average price for each of these crops using the average across the 27 Member States.[915]

Without the use of cover crops, the total 5-year average tonnes of the five top main categories of crop is estimated to be around 260 million tonnes which equates to a value of **EUR 248 billion** (see **Error! Reference source not found.**Table 12-3). However, with the use of legume cover crops this would increase by an addition of 9.2 **million tonnes** which equates to an additional value of **EUR 8.8billion**.

Table 12-3: Baseline of the production of the main cereal types in Europe

Cereal type	5 year average tonnes (2018 – 2022)	Value (EUR)
Common wheat and spelt	124,836,678	25.5 billion
Grain maize and corn-cob-mix	66,487,084	193.0 billion
Barley	52,961,966	9.0 billion
Oats	7,503,636	1.3 billion
Rye and maslin	8,212,232	19.9 billion

[908] https://publications.jrc.ec.europa.eu/repository/handle/JRC129725#:~:text=Although%20we%20cannot%20extract%20a,context%2D%20and%20species%2Ddependant.
[909] https://ec.europa.eu/eurostat/databrowser/view/LAN_LCV_OVW__custom_3784896/default/table?lang=en
[910] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Land_cover_statistics
[911] Agricultural production - crops - Statistics Explained (europa.eu)
[912] https://ec.europa.eu/eurostat/databrowser/view/apri_ap_crpouta/default/table?lang=en
[913] https://ec.europa.eu/eurostat/databrowser/view/prc_hicp_aind/default/table?lang=en
[914] https://ec.europa.eu/eurostat/databrowser/view/APRO_CPSH1__custom_3926713/default/table?lang=en
[915] https://ec.europa.eu/eurostat/databrowser/view/tag00061/default/table?lang=en

Total	**260,000,596**	**248.8 billion**

Table 12-4: Scenario results - 16% increase in yield from the use of legume cover crop

Cereal type	5-year average tonnes (2018 – 2022)	Value (EUR)
Common wheat and spelt	129,284,009	26.5 billion
Grain maize and corn-cob-mix	68,861,125	200.1 billion
Barley	54,831,583	9.3 billion
Oats	7,797,638	1.3 billion
Rye and maslin	8,471,023	20.5 billion
Total	**269,245,378**	**257.7 billion**

Potato yield

Two main root crops are grown in the EU, namely sugar beet (grown on 1.5 million hectares across the EU in 2020) and potatoes (grown on another 1.5 million hectares).[916] Other root crops like fodder beet, fodder kale, rutabaga, fodder carrot and turnips are specialist crops grown on a combined total of only an estimated 0.1 million hectares.

Using data from AHDB which looked at the effect of cover crops on yields of potatoes, root vegetables and cereals, it is possible to calculate a benefit of cover cropping in terms of increased potato yield. The study conducted by AHDB[917] found that on average by using cover crops, potato yield increased by **3 tonnes per hectare.** The study also estimated the standard error around this parameter to be **+/-1.14 tonnes per hectare** from the average. Then these figures are multiplied by the EU price of potatoes over five years (converted to 2021 prices using the latest HCIP)[918] published by Eurostat. Next, this figure is scaled using the figures published by Eurostat which states that potatoes are grown on 1.5 million hectares in Europe. Similar to main crop categories, it is assumed that 23% of soil used for potatoes is left bare over winter.

By using cover crops, the estimated increase in potato yield equates to an additional monetary value of **EUR 767 per hectare (+/- EUR 291).** Applying this to 23% of 1.5 million hectares that is used for potato cropping in the EU (and hence also assuming that 23% of potato cropping in the EU is followed by bare soils over winter) this equates to a total of **EUR 264.5 million (+/- EUR 100.5 million)** in additional value from an increase in yield from cover crops.

According to a paper which looked at maximising the benefits of cover crop through species selection and crop management a recent survey of UK farmers found that the expense of cover crops was cited as one of the main reasons to not grow cover crops. Cover crop establishment and destruction costs includes seed, sprays and cultivations. These costs are reflected in the AHDB data that was used, so this may be due an information gap or market failure were the economic benefits are not fully realised.

[916] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_production_-_crops#Agrometeorological_review
[917]https://projectblue.blob.core.windows.net/media/Default/Research%20Papers/Potatoes/WP3Rotations9114000103RotationsResilience.pdf
[918]https://ec.europa.eu/eurostat/databrowser/view/prc_hicp_aind/default/table?lang=en

Furthermore, land managers may not know how to integrate cover cropping into their crop rotations so there could be a potential knowledge gap.

Reduced nitrate inputs

Overview

Nitrogen (N) is a key input in farm systems for maximising crop growth and yield. Following harvest any residual N in the soil is vulnerable to leaching, and soils may be left exposed to erosion and runoff, in particular if harvest is late (e.g. after maize). Cover crops can be grown to capture some of this leftover N, preventing it from leaching, as well as providing several other agronomic and environmental benefits as mentioned above. Use of mixed cover crops are an effective way of combining the benefits of different species, with their varying rooting structures, agronomic benefits and effect on soil health. Abdalla et al. (2019) reviewed 106 studies, covering different countries, climatic zones and management practices and concluded that cover crops including both legumes, non-legumes and mixes of the two, significantly reduced nitrate leaching compared to stubble/bare ground controls. Several studies looked at the effect of cover crops on water quality across a range of soil types. For example, several trials in Dorset investigated the impact of drilling date and cover crops species on nitrate leaching before maize establishment.[919,920] All these studies show varying degrees of reduced nitrate leaching depending on the crop type, soil type and conditions.

Methodology

For the quantification, evidence on reduced nitrate leaching from cover crop trials was used.[921] Over winter, cover crop trails were performed in three locations over three years covering the vining pea seasons of 2017, 2018 and 2019. Several cover crop species were trialled. Winter vetch, oil radish, a mixture of black oats and berseem clover, and a mixture of phacelia and black oats. Across trials and seasons, it was observed that cover crops captured on average **50 kg N/ha**. Oil radish captured the greatest amount across cover crop species due to its biomass.

Results from cover crop trials are also available from another study.[922] The cover crop used in these trials was oil radish. Oil radish is a widely grown cover crop as it is very effective at capturing nitrogen that might otherwise leach. The key findings showed that oil radish had the greatest uptake of N when drilled early, containing up to **70 kg N/ha** that may be prevented from leaching.

Due to a reduction in nitrate leaching by capturing nitrate in cover crop biomass, land managers have the potential to reduce nitrogen fertiliser inputs during their subsequent cropping season. Therefore, to calculate an economic benefit, figures of captured nitrate combined with fertiliser prices that contain nitrogen were used.

We used fertiliser prices from AHDB for the most commonly used products: Ammonium nitrate (produced and imported), liquid nitrogen (UAN), granular urea, potash and phosphates. They are an average of spot prices and therefore should be used as an indicator of pricing trends. Nitrogen concentrations (percentages in brackets) of these

[919] Wessex Water Cover Crop Trials, Winter 2016-17: Cover crop species and drilling date. Technical Note Winter 2016-17 Wessex Water YTL Group.
[920] Wessex Water Cover Crop Trials, Winter 2017-18: Effect of varying cover crop species and drilling date on nitrogen uptake and leaching. Technical Note Winter 2017-18. Wessex Water YTL Group.
[921] FinalsummaryInvestigatingcovercropsinviningpearotations.pdf (pgro.org)
[922] Wessex Water Cover Crop Trials | Agricology

fertilisers are ammonium nitrate (34.5%), UAN (30%) and granular urea (46%). Savings in fertiliser costs were calculated adjusting for the nitrogen content. Once the prices were scaled up based on their percentage of how much nitrate they contain, all the prices were converted to 2021[923] with a five-year average[924] to smooth out the data. Then an average across the three fertilisers mentioned earlier were taken, which worked out as **EUR 1,037 per tonne.**[925] This was then applied to the amount of reduced nitrate leaching to calculate an avoided cost of fertiliser.

To scale this up to Europe, this figure was applied to the amount of bare soil in Europe from Eurostat[926] which in 2016 was 22,328,980 ha. As mentioned in the introduction, winter cover crops are used on bare soil after the harvest and destroyed late winter before the next crop rotation. Assuming that cover crops would be grown on all bare soil in Europe.

Results

Using the reduction in nitrate leaching of **50kg N/ha,** land managers could reduce cost of nitrate fertiliser of **EUR 52 per ha**. Using the evidence that 23% of arable soil is left bare over winter, if assuming that 23% of soil cover for the main cereal types are left bare over winter (45,834,490*0.23 = 10,541,933). Therefore, the benefit of using cover crops could see a saving in nitrate fertilisers of **EUR 546.8 million pa**. Again, this saving was applied to potato crops. Using the same assumption as above, the benefit of using cover crops could see a saving in nitrate fertilisers of **17.9 million pa.** Scaling this up apply to all arable bare soil in Europe, the benefit of using cover crops could see a saving in nitrate fertilisers of **EUR 1.2 billion pa.**

Using the reduction in nitrate leaching of **70 kgN/ha,** land managers could reduce cost of nitrate fertiliser of **EUR 73 per ha**. If applying this benefit to the area used for the main cereal types in Europe this would equate to EUR 765.5 million pa, and for potato crops this would be 25.1 million pa. Scaling this up to apply to all arable bare soil in Europe, the benefit of using cover crops could see a saving in nitrate fertilisers of around **EUR 1.6 billion pa.**

12.3.4 Summary results

Table 12-5 presents the summary results for the cover crop analysis. The yield benefits and raw material savings for the main cereal types in Europe have a cost benefit ratio of 1:24 whereas for potato yields this ratio is 1:8. In summary, the amount of soils left bare in the EU is significant. This analysis illustrates that if cover cropping were to be implemented over winter, there could be significant yield and raw material saving benefits, that could in many places outweigh the additional costs to land managers. That said, it is important to note that this analysis is only illustrative and there is significant uncertainty around the results, in particular driven by the simplifying assumptions made to facilitate this EU-wide illustration of effects. In particular, the cost and impacts of delivering cover cropping will vary from farm to farm depending on the location and specific parameters of the farm (e.g. climate, soil type, land use) and on the type of cover crops used. The value of the yield benefits will also depend on the crop types deployed in

[923] Using the latest UK GDP deflators: https://www.gov.uk/government/statistics/gdp-deflators-at-market-prices-and-money-gdp-march-2022-quarterly-national-accounts
[924] Just less than a five year average as the data series started in January 2017
[925] Converted using the Bank of England average exchange rate in 2021: Bank of England | Database
[926] Statistics | Eurostat (europa.eu)

the growing season – here illustrating the benefits assuming a mix of cereals in proportion to recent historic outputs across cereal types, and alternatively assuming potatoes are the subsequent economic crop. Benefits will also vary with crop and fertiliser prices, which in themselves are uncertain. Furthermore, data is not available on the impact of cover crops in all locations – therefore the results of a sample of studies which demonstrate the potential impacts in a few specific locations were used, and these effects extrapolated to the whole EU.

Table 12-5: Illustrative estimates of the economic impacts associated with cover crops

	Land area (m ha)	Average cost of cover crops (EUR m pa)	Yield benefit (EUR m pa)	Raw material saving (nitrates) (EUR m pa)
Main cereal types total[927]	45.8	2,759.3	8,801.0	546.8 – 765.5
Potatoes	1.5	90.3	264.5	17.9 – 25.1
All arable bare soil	22.3	5,844.4	N/A[1]	1,158.2 – 1,621.5

1 The yield benefit of applying cover cropping to all bare soil will be reflected in the increase in yield for all arable produce in the spring-summer harvests. Some of the benefit is reflected in the main cereal types and potatoes in the table.

12.4 Reduced tillage

12.4.1 Introduction

Reduced tillage (RT) practices have been reported to offer a multitude of benefits to soil health, particularly in increasing soil organic carbon and reducing soil erosion.[928] The principle behind reduced tillage is to minimise soil disturbance, however the intensity of this reduction can vary, from intensive deep RT to very minor soil disturbance under zero tillage management.[929] In a review of the impact of sustainable soil management practices in Europe it was reported that reduced tillage was practiced to some extent across all regions, however only across very small areas of land.[930] This suggests the applicability of reduced tillage across the EU, but also the scope to expand its implementation and improve soil health.

The environmental benefits of reduced till are well reported, contributing to improved soil health and GHG emission mitigation, however the economic benefits are more complicated which possibly accounts for its current low uptake. Crop yields often decrease under reduced tillage in the short term, particularly in the first 3-4 years for cereals and legumes, and 5-10 years for other crops.[931] When analysing the performance of a variety of crops, the negative impacts of no-till decreased when crop rotation and residue retention practices were implemented.[932] Despite this impact on yield, reduced tillage is often still reported to be economically beneficial to land managers, with some

[927] Main cereal types include; Common wheat and spelt, Grain maize and corn-cob-mix, Barley, Oats and Rye and maslin
[928] Analysing reduced tillage practices within a bio-economic modelling framework. - Abstract - Europe PMC
[929] Ibid.
[930] Deliverable_2.1_Synthesis_of_the_impact_of_sustainable_soil_management_practices_in_Europe.pdf (ejpsoil.eu)
[931] Pittelkow et al. (2015), When does no-till yield more? A global meta-analysis
[932]Ibid.

farmers reporting savings of 79-102 EUR per ha per year,[933] through a reduction in the costs of inputs associated with reduced tillage.

12.4.2 Quantified Costs

Overview

The key cost of reduced tillage is likely to be the negative impact on yield, and therefore this will be quantified in this section.

Methodology

To quantify the impacts of reduced tillage on yield, data was gathered on yield of cereal crop under conventional tillage and yield of cereal crop under reduced tillage (all in tonnes per hectare). The percentage change in yield resulting from reduced tillage was calculated for each of these data points, and the average and range of these points was then determined (see table below). Due to limitations of data availability and timeframe, values for specific crop types was not able to be extrapolated, and therefore a mixed cereal aggregate value was calculated and used in the scale up.

These papers all looked at the difference in yield of cereal crops grown in Europe under various reduced tillage methods, compared to a conventional tillage control. While they are all Europe based, the site demographics vary on factors including climate, soil type, rotation type etc. Furthermore, the definition of reduced tillage/the intensity of the reduced tillage treatment varies among these data sources which is another factor accountable for the range of results observed. This, however, can offer a more practical dataset to quantify the impacts of implementing this practice across large areas of the EU, which will display similar variations in soil type, climate, and suitability for various tillage intensities.

Table 12-6: Summary of the impacts of reduced tillage compared to conventional tillage on yields of various cereal crops across Europe

Treatment	Region	Yield Impact (%)
Reduced Tillage	Germany	-22.0
Reduced Tillage	Germany	-43.0
Conservation Tillage	Europe	-4.5
Reduced Tillage	Europe	-13.0
Reduced Tillage	Europe	-4.0
Reduced Tillage	Switzerland	+15.0
Reduced Tillage	UK	-3.0
Reduced Tillage	UK	-8.0
Reduced Tillage	Denmark	+4.0
Reduced Tillage	Denmark	-2.0
Reduced Tillage	Denmark	-3.0
Minimum		-43.0
Average		-7.6
Maximum		+15.0

[933] Valuing_Your_Soils_PG.pdf (farmingforabetterclimate.org)

This average impact factor of cereal yield was multiplied by the 5 year average yield (in tonnes) for the 5 main crop types grown in Europe (taken from EUROSTAT). This gives an indication of the impact on cereal crop yields that would be felt if all these were to be grown under reduced tillage. This is not a precise forecast of the yield change as there are many variable factors which can affect this rate (such as those listed above), as well as this relying on the assumption that 100% of these crops are currently grown under conventional tillage which is not true.

The area of arable land under various tillage management practices was extrapolated from the Eurostat Database (2016). The impacts (in 'unit' per hectare) could then be scaled up to offer a quantification of implementing reduced tillage across the entire area of arable land in the EU currently under conventional tillage. A key limitation to this calculation is that the most recent data available for this is from 2016.

Results

Data on the impact of tillage intensity on the yield of cereal crops across Europe was gathered from a variety of sources (Syngenta and ScienceDirect). The yield percentage change was calculated from this data and an average yield impact was determined. The impact range was found to be from a **43%** decrease to a **15%** increase in yield, with an average impact of **-7.6%.**

The table below shows the estimated impact on yield and value from these yields if reduced tillage was implemented across the area of EU land which is currently under conventional tillage management. This shows that introduction of reduced tillage across this area will reduce value from grain crops by an approximate 12.9 **billion EUR pa.**

Table 12-7: Impact on total EU yields and the value of these crops if reduced tillage was implanted across the EU (assuming an 8.6% decrease in yield) (on the 68.15% of land area covered by conventional tillage)

Cereal type	Yield (tonnes)	Value (EUR)	Change in yield (tonnes)	Change in value (EUR)
Common wheat and spelt	78,437,382	16,056,131,997	- 6,451,560	- 1.32 billion
Grain maize and corn-cob-mix	41,775,165	121,390,273,350	- 3,436,053	- 9.98 billion
Barley	33,277,062	5,623,823,559	- 2,737,074	- 0.462 billion
Oats	4,714,685	786,391,471	- 387,788	- 0.064 billion
Rye and maslin	5,159,910	12,492,141,166	- 424,408	- 1.03 billion
Total	**163,364,203**	**156,348,761,543**	**- 13,436,882**	**- 12.9 billion**

Impacts of reduced till on yield vary in the literature and are dependent on a variety of factors that are difficult to isolate, including: soil type, climate, crop types, specifics of the tillage operations (no. of passes, machinery, depth of disturbance), other cropping practices (rotations, cover/catch crops), and seeding rate. However, the average impact is a reduction of 8.6%, and in the majority of instances a reduction in yield was measured. There are multiple factors that have been suggested as causing this negative impact including poor incorporation of crop residues, increase in grass weeds and volunteers (which increase competition for resources), and topsoil compaction, especially when associated with poor drainage (AHBD, 2015) (HGCA, 2002). The decreased yields from reducing tillage are likely due to less homogenous planting conditions, less drainage of excess water, and less aeration of soil.[934] These can all reduce crop emergence and performance.[935]

12.4.3 Quantified Benefits

Overview

As previously stated, the introduction of reduced tillage has significant environmental benefits, but also a strong economic benefit. This can come from increased yields where reduced tillage is implemented over the long term, and where implementation is optimal (i.e. as part of a system with other sustainable soil management practices including cover cropping and effective nutrient management).[936] However, the economic benefit is often actualised straight away due to the significant reduction in operations and the related costs (labour, machinery, etc.). This section will quantify these savings to allow for an analysis of the overall costs and benefits of introducing reduced tillage.

Methodology

Operational costs which could be reduced by RT include: fuel use, machine costs, labour, and chemical inputs. Some sources specified values for each of these costs, while others simply reported overall costs of producing the crop. In this quantification costs reported in Townsend T.J. et al. (2016) were used, as this offered Europe-centric costing and gave the breakdown of where the total costs was calculated from. Where these were given in units other than 2021 EUR per ha, the values were converted, using appropriate inflation and currency conversion rates. The table below provides a breakdown of the costs of operations for both conventional and reduced tillage used in this section, taken from Townsend, T.J., et al. (2016).[937]

Table 12-8: Summary of operation costs associated with conventional and reduced tillage

Costs	Conventional tillage costs	Average of reduced tillage costs
GM (£ ha− 1)	714.00	871.00
Machinery (£ ha− 1)	296.00	241.80
Fuel (£ ha− 1)	148.00	80.40
Labour (£ ha− 1)	69.00	45.20
Net margins (£ ha− 1)	432.00	629.20
Total Costs (£ ha-1)(2016)	513.00	367.40
Total Costs (£ ha-1)(2021)	576.87	413.14
Total Costs (EUR ha-1)(2021)	**671.07**	**480.61**
Change compared to CT (%)		-28.38

Results

Average operational costs for conventional tillage for cereal crops is **671.07 EUR per ha**, while reduced tillage resulted in an operational cost for cereal crops of **480.61 EUR per ha.** This means reduced tillage can create a **28.38%** reduction in operation costs, which is the equivalent of **190.40 EUR per ha.**

[934] Van den Putte et al., (2010), Assessing the effect of soil tillage on crop growth: A meta-regression analysis on European crop yields under conservation agriculture
[935] Ibid.
[936] Pittelkow C.M. et al., (2015), When does no-till yield more? A global meta-analysis
[937] https://europepmc.org/article/PMC/4913617#abstract

According to EURSOTAT data 62,506,360 ha of arable land are under conventional tillage (EUROSTAT 2016). This means there is approximately **41.9 billion EUR** being spent on production of arable crops under conventional tillage, which could be reduced by **28.38%** to **30.04 billion EUR**, for a saving of **11.9 billion EUR**.

Table 12-9: Shows the cost of conventional and reduced tillage on the area currently covered by conventional tillage in the EU and the saving created

Area covered by conventional tillage (ha)	Cost of Conventional Tillage (EUR)	Cost of Reduced tillage (EUR)	Saving (EUR)
62,506,360	41.9 billion	30.04 billion	11.9 billion

A key risk of reducing tillage is increased need for weed control/plant protection products/herbicide application. Estimates for costs of this from literature range from **35-100 EUR per ha.**[938] This can vary depending on the intensity of the tillage and in general the lower the tillage intensity, the greater need, and therefore cost, of weed control. This additional cost of 35-100 EUR per ha represents a significant portion of the savings calculated above of 190 EUR per ha, meaning savings per ha could be reduced by approx. 18-53%. The table below gives a summary of the cost of conventional and reduced tillage when factoring in the range of possible additional weed control costs, and the savings for each possibility.

Table 12-10: Shows the cost of conventional and reduced tillage on the area currently covered by conventional tillage in the EU and the saving created, factoring in possible additional costs for weed control

Area covered by conventional tillage (ha)	Cost of Conventional Tillage (EUR)	Cost of Weed Control (EUR)	Cost of Reduced tillage (EUR)	Saving (EUR)
62,506,360	41.9 billion	0	30.04 billion	11.9 billion
		35	32.2 billion	9.71 billion
		100	36.3 billion	5.65 billion

Operation cost savings will vary depending on a number of factors. The costs involved in these operations are machinery, labour, seeding rate, changes in additives (herbicides, pesticides, fertilisers). A variable factor is whether the necessary machinery is owned, hired, or contracted out. Reducing tillage can increase weed emergence, which will require increased plant protection costs (spraying of herbicides). Lowest tillage rates (lower depth, fewer passes, lower disturbance) tends to create higher savings on costs, but lower overall yields so this compromise has to be made to optimise the implementation of this measure. Smaller farms may not benefit economically from reducing tillage – at least not as much as larger farms.

In these estimations there have been a number of assumptions made due to the limited availability of pertinent data. For instance the land cover data is from 2016, so this may not still be reflective of the true management of arable land today, however this is the

[938] Lutman P. J. W. et al., (2012), A review of the effects of crop agronomy on the management of Alopecurus myosuroides

most recent, reliable data available from EUROSTAT. When scaling these calculations up to estimate the impact across the EU, the figure of 68.15% has been used for the portion of arable land under conventional tillage. This has been applied to the yield of cereal crops taken from Eurostat to estimate the proportion of each crop that is grown under conventional tillage, and therefore available to be switched to reduced tillage. However, this may not be completely reflective of the current management of arable land, as the entire area of land under conventional tillage could be used to grow other crops (e.g. vegetables).

12.4.4 Summary

The estimations carried out have found that reduced tillage will result in approximately an average 116 EUR per ha saving for various cereal crop types, which is line with other reports of savings from introduction of reduced tillage[939]. The table below summaries the estimated cost and benefit change on a per hectare bases, if reduced tillage was implemented. This summary could only be carried out for wheat and barley as these are the only two crops that a yield in t/ha was available for on EUROSTAT.

The results of this analysis suggest that the profit increase level will vary depending on the crop type, while the actual amount is in the range of **108-123 EUR per ha**. Some of the calculations resulted in an appropriate actual figure however, the percentage was out of the range expected which is likely an artefact of the calculations. This range calculated here is fits with that reported by some farmers (quoted in Introduction) of 79-102 EUR per ha. However, the values here are slightly higher possibly due to variation in yields, different crops looked at, or slightly different operations involved.

Table 12-11: Summarising the change in economic costs and benefits for various crop types due to a change from conventional to reduced tillage

	Conventional tillage	Reduced tillage
WHEAT		
Yield (t/ha)	4.67	4.27
Price (EUR/100kg)	20.47	20.47
Price (EUR/t)	204.73	204.73
Revenue (EUR/ha)	***956.08***	***873.86***
Cost (EUR/ha)	***671.00***	***480.60***
Profit (EUR/ha)	**285.08**	**393.26**
Profit Increase (EUR/ha)		108.18
Profit Increase (%)		37.95
BARLEY		
Yield (t/ha)	4.61	4.22
Price (EUR/100kg)	16.90	16.90
Price (EUR/t)	169.00	169.00
Revenue (EUR/ha)	***779.54***	***712.50***
Cost (EUR/ha)	***671.00***	***480.60***
Profit (EUR/ha)	**108.54**	**231.90**
Profit Increase (EUR/ha)		123.36

[939] Valuing_Your_Soils_PG.pdf (farmingforabetterclimate.org)

Profit increase (%)		113.65

The table below presents the summary impacts extrapolated to EU-wide level. As shown, the costs through yield loss are large but the savings through reduced operational costs can also be significant – in this case the two broadly net out. The positive economic impact of reduced tillage is likely to be furthered over time, as soils become healthier and can therefore support higher yields or will require lower artificial inputs, which is not captured here. A key uncertainty, and possible additional cost is the protection requirements against weeds. When factoring these in the benefits are vastly reduced, however, with effective implementation of reduced tillage within a comprehensive soil management plan, should still yield an economic benefit.

Table 12-12: Illustrative EU wide impacts

Impact category	Illustrative EU-wide value estimate (EUR bn per annum)
Yield loss	-13 EUR bn
Operational cost savings	12 EUR bn
Net impact	**-1 EUR Bn**
Operational cost savings (including additional weeding costs)	*5.7 to 9.7 EUR bn*
TOTAL (incl. additional weeding costs)	***-3.3 to -7.3 EUR bn***

However, to reiterate the points made throughout this section, the actual impact of this measure will vary depending on a number of factors, and the values quoted here are estimates and not precise quantifications of the impacts. The shallower the reduced tillage, the greater the opportunity for cutting costs but in general the greater the risk of losing yield.[940] Moreover, some of the data from EUROSTAT is from 2016, and some assumptions, such as an equal proportion of each crop type being grown under conventional tillage, which may slightly reduce the accuracy of the conclusions.

12.5 Crop rotations

12.5.1 Introduction

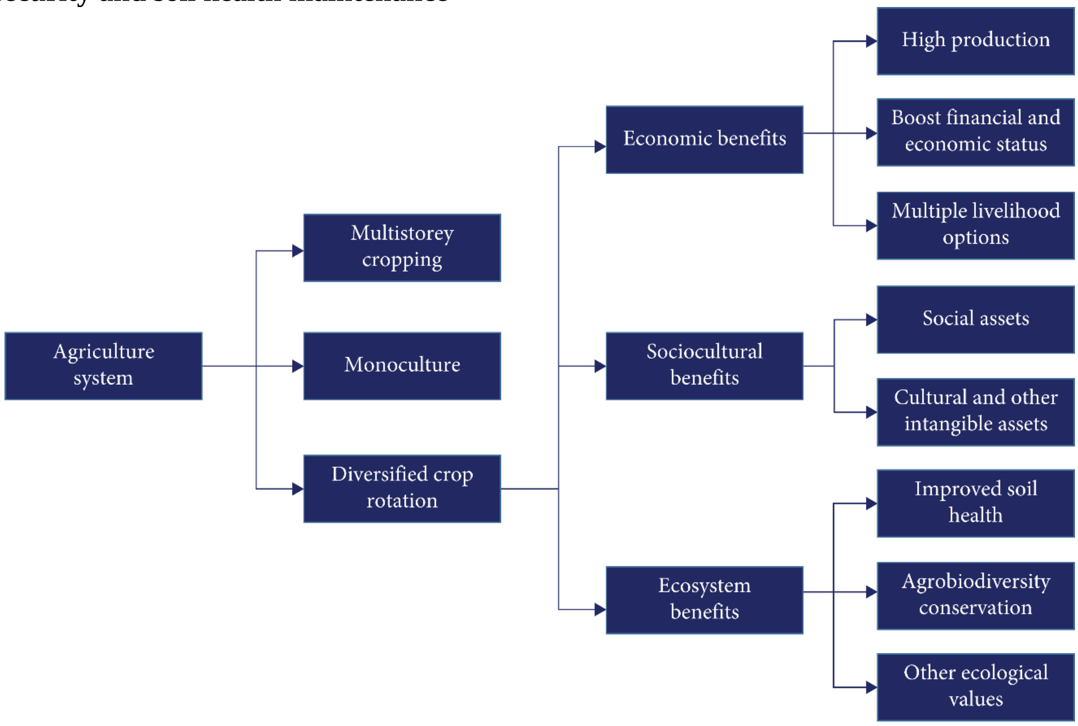
Crop rotation is the agronomic practice of growing crops on the same paddock in sequence[941]. It has several benefits for soil and crop systems which include:

- Lower incidence of weeds, insects, and plant diseases.
- Improvements of soil physical properties which include better water holding capacity and aggregate stability.
- Improvements in biological properties which include an increase in organic matter, which replenishes soil nitrogen (N) and carbon.
  - Reduction in greenhouse gas emissions because of the lower amount of N fertilizer added for example, if cereal crops follow a leguminous crop, the rotation can fix atmospheric N through rhizobacteria.

[940] Reduced cultivations for cereals: research, development and advisory needs under changing economic circumstances.pdf (windows.net)
[941] https://www.sciencedirect.com/referencework/9780080931395/encyclopedia-of-agriculture-and-food-systems

Figure below shows gives an overview of the benefits of crop rotations (called diverse cropping systems).

Figure 12-1: Conceptual Framework of importance of diverse cropping systems (DCR) in food security and soil health maintenance



Source: https://www.hindawi.com/journals/aag/2021/8924087/

Many crops can be included into different crop rotations. Hence to ensure that maximum benefits from applying the practice are achieved, a number of rules and criteria should be applied. According to a study of the European Commission[942] optimal rotations should include:

- Cash (e.g. maize) and soil-conserving cover crops (e.g. clover);
- Deep-rooted (e.g. sweet clover, alfalfa) and shallow-rooted crops (e.g. cereals) to maximise nutrient availability along the soil profile;
- Spring- and autumn-sown crops to break the life cycles of weeds, pests and pathogens;
- Crops with a high level of ground cover (i.e. to maintain weeds to be easily controlled mechanically)
- Water-demanding crops (e.g. maize) and those that require less water (e.g. barley);
- Crops that leave a large amount of plant residues after harvest;
- N2 fixing legumes and high-N consumers (e.g. maize and winter wheat)
- More than one densely cultivated fast-growing crop (i.e. intercropping, cover crops or catch crops), as this maximises nutrient efficiency, reduces weeds through increased competition, protects soil structure, minimising soil erosion, and provides different habitats for fauna, including beneficial insect pollinators.

[942] https://ec.europa.eu/environment/agriculture/pdf/BIO_crop_rotations%20final%20report_rev%20executive%20summary_.pdf

Although diversified crop rotation is one of the main practices suggested to obtain ecological benefits by arable systems, there is only limited evidence around the impact on farm profitability.[943] As reported by Rosa-Scheich et al. 2019 review,[944] there are few systematic meta-analyses useful to compare effects on costs saving, increase of gains or improve land profitability stability across regions. To illustrate the potential costs and benefits, a case study in Finland was used as a basis which looked at an economic assessment of a diversified feed cereals production.[945]

12.5.2 Quantified costs

One of the main challenges to the adoption of using crop rotation is financial, as integrating extra crops into normal rotations may require farmers to make significant upfront investments, such as new machinery, and impose an additional short-term cost. The case study in Finland also looked at potential seed costs for catch and cover crops (however, in their conclusions they state that the costs of seeds for cover or catch crops is cancelled out by a reduction of nitrogen fertiliser so they conclude that there is little or no economic loss or gain realised). The average variable costs and subsidies of the crops were derived from a recent version of a dynamic regional sector model of Finnish agriculture (DREMFIA) (Lehtonen, 2001[946]; Lehtonen and Niemi, 2018[947]), which relies on validated approximations of the average use of inputs per crop in each region.

If the variable costs, labour costs and machinery costs are used when introducing oilseed rape into the third-year rotation, these costs increased by 61 Euros when compared with barley mono-cropping (this also includes an assumption that nitrogen fertiliser costs will reduce if this assumption is removed the additional costs would be EUR 140).

The table below shows the breakdown of the difference in crops between the baseline (barley monocropping) and the diversified crop rotation.

Table 12-13: Difference in costs between monocropping and diversification which assumes that nitrogen fertiliser will be reduced

Year		1	2	3	4	5	
Rotation	Units	Barley	Barley	Oilseed rape	Barley	Barley	Total
Variable costs	EUR/ha	0	0	88.7	-43.7	0	45
Labour costs	EUR/ha	0	0	-0.4	0	0	-0.4
Machinery costs	EUR/ha	0	0	16	0	0	16

[943]https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5d4f9001c&appId=PPGMS
[944] https://www.sciencedirect.com/science/article/pii/S0921800918301277?via%3Dihub
[945]https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5d4f9001c&appId=PPGMS
[946] Lehtonen, H., 2001. Principles, structure and application of dynamic regional sector model of Finnish agriculture. Agrifood Research Finland, Economic Research (MTTL).
947 Lehtonen, H., Niemi, J., 2018. Effects of reducing EU agricultural support payments on production and farm income in Finland. Agric. Food Sci. 27, 124–137. https://doi.org/https://doi.org/10.23986/afsci.67673

12.5.3 Quantified Benefits

Methodology

Calculation of benefits also uses the Finland case study as a basis. To calculate the benefits, the study used 15 years of historical data (2000–2015) for crop yields, variable costs and subsidy data. The average crop yields were extracted from official farm statistics[948] for the Varsinais-Suomi region in Finland.

The study then deployed a number of hypotheses where they looked at the impacts of crop rotation on;

1. Reduced need for nitrogen
2. Reduced need for crop protection
3. Additional seeding (see costs) and reduced nitrogen fertilisation
4. Yield – they assume that crop yields will decrease every year from undertaking monoculture (producing the same crop type every year).

These impacts are shown in the results section but for more information on the methodology see the source paper.[949] For the results discussed, focus was on the diversified rotation of barley – winter rapeseed – barley because this example shows the benefits of purely crop rotation whereas the other rotation used in the paper (oats- barley- spring wheat- oats- barley) combines crop rotation with spring cereals (oats- barley- spring wheat- oats and barley) with no tillage.

Results

The analysis of the case study focused on assessing a change from cereal monocultures to diversified crop rotations in southern Finland. They calculated the gross margins if they carried on with monoculture and these are shown tables below.

[948] https://stat.fi/en/topic/agriculture-forestry-and-fishery
[949] https://cordis.europa.eu/project/id/728003

Table 12-14: Gross margin calculation of barley monocropping, as a base of comparison (EUR)[950]

Years		1	2	3	4	5	
Rotation	**Units**	**Barley**	**Barley**	**Barley**	**Barley**	**Barley**	**TOTAL over 5 years**
Crop yield	kg/ha	3814.0	3814.0	3814.0	3814.0	3814.0	19070.0
Market revenues	EUR/ha	489.9	489.9	489.9	489.9	489.9	2449.4
Subsidies	EUR/ha	479.0	479.0	479.0	479.0	479.0	2395.0
Variable costs	EUR/ha	517.3	517.3	517.3	517.3	517.3	2586.6
Gross margin A	***(Market revenues + Subsidies) – Variable costs***	***451.6***	***451.6***	***451.6***	***451.6***	***451.6***	***2257.8***

Reduced nitrate use for barley

As mentioned previously, crop rotation can lead to improvements in biological properties which include an increase in organic matter, which replenishes soil nitrogen (N) and carbon. Therefore, there will be a reduced need for nitrogen fertilisers. The main increase in Gross Margin A in Table 12-14 compared to Table 12-15 (the gross margin after variable inputs excluding labour) is caused primarily from the higher gross margins of oilseeds compared to barley, and the reduced need of fertilizer of crop protection for barley (year 4) after oilseeds.

Table 12-15: Gross margin calculations assuming reduced nitrogen fertilisation due to diversification[951]

Years		1	2	3	4	5	
Rotation	**Units**	**Barley**	**Barley**	**Oilseed rape**	**Barley**	**Barley**	**TOTAL over 5 years**
Crop yield	kg/ha	3814.0	3814.0	2000.0	3814.0	3814.0	17256.0
Market revenues	EUR/ha	489.9	489.9	595.1	489.9	489.9	2554.6
Subsidies	EUR/ha	479.0	479.0	552.0	479.0	479.0	2468.0
Variable costs	EUR/ha	517.3	517.3	606.0	473.6	517.3	2631.5
Gross margin A	***(Market revenues + Subsidies) – Variable costs***	***451.6***	***451.6***	***541.1***	***495.3***	***451.6***	***2391.1***

Yield

The study assumes that yield will decrease by 5% every year due to monoculture and this is demonstrated, tables below shows the yield from introducing different crops into the

[950] https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5d4f9001c&appId=PPGMS
[951] ibid

rotation. For this comparison, the data that looked at conventional tillage is presented to show the benefits purely from changing to a more diversified crop rotation. This example does not include the benefits of reduced fertiliser use. By adding oilseed into the rotation, the gross margin A increased by 13.5% and gross margin B by 26%, over a 5-year period.

Table 12-16: Gross margin calculations assuming crop yield loss – conventional tillage and barley monoculture[952]

Years		1	2	3	4	5	
Rotation	Units	Barley	Barley	Barley	Barley	Barley	TOTAL over 5 years
Crop yield	kg/ha	3814.0	3623.3	3442.1	3270.0	3106.5	17256.0
Market revenues	EUR/ha	489.9	465.4	442.1	420.0	399.0	2216.4
Subsidies	EUR/ha	479.0	479.0	479.0	479.0	479.0	2395.0
Variable costs	EUR/ha	517.3	517.3	517.3	517.3	517.3	2586.6
Gross margin A	***(Market revenues + Subsidies) – Variable costs***	***451.6***	***427.1***	***403.8***	***381.7***	***360.7***	***2024.8***

Table 12-17: Gross margin calculations– conventional tillage and breaking barley monoculture with oilseed rape[953]

Years		1	2	3	4	5	
Rotation	kg/ha	Barley	Barley	Oilseed rape	Barley	Barley	TOTAL over 5 years
Crop yield	EUR/ha	3814.0	3623.3	2000.0	3814.0	3623.3	16874.6
Market revenues	EUR/ha	489.9	465.4	595.1	489.9	465.4	2505.6
Subsidies	EUR/ha	479.0	479.0	552.0	479.0	479.0	2468.0
Variable costs	EUR/ha	517.3	517.3	606.0	517.3	517.3	2675.3
Gross margin A	***(Market revenues + Subsidies) – Variable costs***	***451.6***	***427.1***	***541.1***	***451.6***	***427.1***	***2298.3***

12.5.4 Summary

EU level

In terms of costs, using the increase presented in Table 12-13 which estimates that total costs would increase by EUR 61 per ha over a five-year period (includes labour, variable

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952 ibid

953 Antonious G.F., (2016), Soil Amendments for Agricultural Production

costs and machinery costs and also assumes that nitrate fertiliser will reduce after implementing a different crop) by introducing a crop rotation into the land that is used for barley production in the EU (10,324.79 thousand hectares in 2022) this would mean that costs for all land used for barley would increase by EUR 0.6 billion.

In terms of benefits, using the figures presented in Table 12-18 market revenues will increase from introducing a different crop in this case oil-seed rape by EUR 289.2 per ha over a 5-year period, which is partly due to a greater increase in barley yield after the implementation of oilseed rape. Applying this to all land that is used for growing barley in the EU the additional benefit would be EUR 3.0 billion, making the total market revenue EUR 25.9 billion over five years.

Table 12-18: illustrative EU-wide costs and benefits

	Crop rotation to applied to all land in EU used for barley production EUR billion
Additional costs over 5 years (EUR)	0.6
Additional benefits over 5 years (EUR) – increased yield	3

12.6 Use of Organic Manures

12.6.1 Introduction

The use of organic soil amendments provide a source of nutrients for soil that is alternative to synthetic inorganic fertilisers that often come with increasing costs, high emissions from production, and issues of soil, water, and air contamination.[954] A key benefit to the use of organic materials as fertilisers is the slow release of nutrients to the soil and plants, as they require mineralisation to become available, thus reducing nutrient leaching. And as nutrients are valuable resources of an ecosystem, saving these nutrients in the soil can be viewed as saving money. Microbiological activity, structure, and organic carbon levels of soils have all reportedly been improved through incorporation of organic amendments.[955] The variety of benefits of this measure, its wide applicability, and its potential for improved economic return are why this has been selected for quantification.

12.6.2 Quantified Costs

Raw Material

In the context of a livestock farm growing silage grass or fodder maize, the assumption is made here that there will be no raw material cost as manure is a by-product of the system. If not recycling this material back into the soil, it will be considered a waste product, which will then create a complex issue around storage, transport, and other handling/logistics of the manure. The costs of storage facilities and application equipment will be considered in the Operations section.

[954] Ibid.
[955] Ibid.

Operations

The costs of storage facility, and the cost of application equipment are considered here. However, these may be upfront capital expenses for equipment rather than ongoing costs. This differs where a contractor is brought in to spread the manure, in which case the costs of spreading/application will be ongoing.

This quantification is based on a range for contractor costs for spreading, as time and data availability was limited. This was found to be in the range of **465-2559 EUR pa.**[956] A figure for this cost could not be found per ha so this range is used per holding and the actual value may depend on the application area, rate, and type of spreading and manure used.

Alternatively, where external contractors are not used, the cost of installing a storage facility is going to be a large capital expense, while the returns will be much smaller but continuous, as discussed in the section below. This can make it seem that the costs greatly outweigh the benefits of this measure, however, the ongoing savings, as well as multiple other benefits, need to be considered. The size of storage facility needed will be dependent on the management of the livestock (i.e. the species of animal or feed type), and the management of the land (i.e. the quantity of manure being spread). The cost of a manure storage facility was estimated using data taken from the report *Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs.*[957]

Table 12-19: Estimates of the cost of installing manure stores of different sizes[958]

Tank Size (m^3)	Cost (EUR/m^3 pa)	Cost (EUR pa)
500	2.16	1,078
1000	1.90	1,902
3000	1.56	4,688
5000	1.42	7,087

Total costs are summarised in the table below. These costs vary dependent on a range of factors. A key cause of variation here is related to application and storage methods that are environmentally friendly also tend to be the most expensive. However, this can be seen as an important investment as sustainable practices are likely to become more required in the future.

Table 12-20: Summary of the estimated costs of starting to store and apply manure to soils

Category	Cost (EUR pa)
Storage Facility	1,078 - 7,087
Application	465-2,559
Total	**1,543 - 9,646**

[956] Sykes J., (2019), Application of BAT to a wider range of livestock rearing
[957] Germán Giner Santonja, Konstantinos Georgitzikis, Bianca Maria Scalet, Paolo Montobbio, Serge Roudier, Luis Delgado Sancho; Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs; EUR 28674 EN; doi:10.2760/020485
[958] Ibid

12.6.3 Quantified Benefits

Introduction

Addition of manures to soil has the ability to increase nutrient and carbon content of soils, which has the potential to increase the yield of crops grown on this land. However, like many SSM practices, this crop performance improvement can often only be observed over time. This is due to the slow release of organic N form manure compared to that of mineral N from inorganic fertilisers, as well as the time it takes to build up organic carbon stocks in soil. Therefore, reported data on the impact of spreading organic manures varies from slight decreases in yield to significant increases.

Furthermore, the application rate has been found to have a significant influence on the yield impact achieved. Higher application rates tend to result in higher yields, open until a certain point after which it can have a decreasing impact. The slow release of N from organic sources compared to inorganic sources, and therefore the lower availability, has been cited as a reason for this impact.

For the purposes of this quantification, it is assumed that the application of manure would reduce the use of chemical fertilisers, while only providing nutrients to meet the requirements of the crops. Therefore, there is no change of yield is assumed so no economic cost or benefit from this. The important economic benefit to applying manure is the increased savings from the reduced need to pay for chemical fertilisers.

Methodology

Example calculations on the cost savings from lower chemical nutrient use have been taken from 'Making better use of livestock manures on grassland' (ADAS, Institute of Grassland and Environmental Research, and Silsoe Research Institute)[959]. These calculations are summarised in **Error! Reference source not found.** to 12-24 below. These calculations involved estimating the requirements of the particular crop grown, the available nutrient supply of organic manure, and calculating the cost of inorganic nutrients still required to meet the crop's requirements.

All prices in these example documents were updated to reflect the current fertiliser prices. Fertiliser prices were taken from AHDB (See Section on Cover Crops on how price for nitrogen was calculated). A similar methodology was followed for calculating a price for phosphorous and potassium. The prices across five years were equated to 2021 prices, and then a five year average for each was taken to smooth out the data. An average these values was then taken for the two phosphorus based fertilisers (Diammonium Phosphate and Triple Super Phosphate), while the five year average price of Muriate of Potash was used as a price for potassium. The prices for each nutrient were **1,037, 494, and 390 EUR per tonne respectively.**

Results

The calculations summarised in tables below found that manure can save costs on chemical fertilisers in the range of **82-140 EUR per ha.**

[959] archive (nutrientmanagement.org) archive (nutrientmanagement.org)

Table 12-21: Summary of nutrient savings estimated through application of 12.t/ha of layer manure to first cut silage grass

	N	P2O5	K2O	Value (£/ha)
Available Nutrients (kg/t)	5.6	7.8	8.1	
Applied Nutrients (kg/ha)	70	160	100	
Requirements (kg/ha)	120	40	110	187
Artificial Nutrient Need (kg/ha)	50	0	10	
Artificial Nutrient Use (kg/ha)	50	0	32	64
Saving				***123***

Table 12-22: Summary of nutrient savings estimated through application of 40m3 of cattle slurry after first cut silage grass

	N	P2O6	K2O	Value
Available Nutrients (kg/m^3)	0.6	0.6	3.2	
Applied Nutrients (kg/ha)	24	48	125	
Requirements (kg/ha)	100	25	100	155
Artificial Nutrient Need (kg/ha)	75	0	0	
Artificial Nutrient Use (kg/ha)	70	0	0	73
Saving				***82***

Table 12-23: Summary of nutrient savings estimated through application of 30t/ha of cattle FYM before forage maize

	N	P2O7	K2O	Value
Available Nutrients (kg/t)	1.2	2.1	7.2	
Applied Nutrients (kg/ha)	35	105	215	
Requirements (kg/ha)	80	60	205	193
Artificial Nutrient Need (kg/ha)	45	0	0	
Artificial Nutrient Use (kg/ha)	51	0	0	53
Saving				***140***

According to EUROSTAT there was 48,865,000 ha of land under permanent grassland management, which gives an indication of the area of land which this saving can be applied to.[960] However, this is not entirely accurate as manure is likely applied to some of this area already. There was no data available on the area of land that has currently manure applied to it. By contrast, a five year average of the total inorganic nitrogen consumption across the EU was 11,194,255 tonnes.[961]

These costs benefits are on a per hectare basis however, while the quantified costs above are per holding. To allow for greater comparison, the average size, in hectares of a holding in the EU was calculated from data from EUROSTAT.[962] The total area of utilised agricultural area was divided by the total number of holdings, both in 2020, which resulted in an average holding size of **17.4 ha per holding** (157,427,540 ha

[960] Statistics | Eurostat (europa.eu) Statistics | Eurostat (europa.eu)
[961] https://ec.europa.eu/eurostat/databrowser/view/aei_fm_usefert/default/table?lang=en
[962] Statistics | Eurostat (europa.eu)

/9,070,970 holdings =17.4). Using this value, the estimated benefit per holding is approximately in the range of **1,427-2,436 EUR per holding.**

12.6.4 Summary

The table below summaries the key costs and benefits for introducing organic manure application to soil. The key costs included here are the installation of a storage facility and the ongoing costs of application by a contractor, while they benefit comes from savings from reduced need for inorganic fertilisers.

Table 12-24: Summary of the key quantified economic costs and benefits of using organic manure on soil

Impact category	Impacts on holdings (EUR per year)
Costs	**-1,543 to -9,646**
Benefits	+1,427 to +2,436
TOTAL	**-8,219 to 893**

The above summary focuses on the impacts of introducing manure storage and spreading on a per holding basis. To scale this up and estimate the impacts at the EU level, there is an assumption made that there are already holdings that have the facilities and are implementing this practice. It is assumed that 17-19% of holdings do not have a storage facility, suggesting that this is the proportion of holdings that the above impacts will apply to. This figure is taken from a study of Welsh farms, so may not be an accurate reflection of the application in the EU, however it is the most recent data available. A summary of the impacts of implementing manure storage and spreading at an EU level (17-19% of holdings with livestock) is presented in table below.

Table 12-25: Summary of the key estimated economic impacts of implementing manure application on an EU level

Impact category	Impacts on holdings (EUR pa)	Estimated EU Impacts	
		17% of holdings (EUR pa)	19% of holdings (EUR pa)
Costs	**-1543**	-1.5 billion	-1.68 billion
	-9646	-9.4 billion	-10.5 billion
Benefits	1427	1.39 billion	1.55 billion
	2436	2.37 billion	2.65 billion
TOTAL	**893**	0.87 billion	0.97 billion
	-8219	-8.01 billion	-8.95 billion

From the above table, it can be seen that the estimated overall impact of starting manure storage and spreading on an EU level could fall in the range from a net cost of €8.9bn pa to a benefit of €1.0bn pa. The key factors this depends on are the number of holdings that require a manure store and the type of store and spreading method that is selected.

This quantification focuses on systems involving livestock production and land growing crops for feed. This does not include then the potential costs and benefits to come from application of organic manure to soil under arable management. There is also the potential to apply organic manure to these soils, however the quantification is more complex and the data is more limited to cover this, so it has been left out of this quantification. Quantification is more complex as the farm system will not have any manure as a natural by-product, so would have to acquire the material. There are a variety of example of how this can be done, including paying for, being paid to take it, and exchange scheme were the cost would be zero.

While benefits do not necessarily outweigh costs initially, the one-off payment of installing the storage facility is the key cause of this. With time the nutrient savings should remain stable while the costs should reduce.

12.7 Reduced Stocking Density

12.7.1 Introduction

High stocking densities can damage soil health by causing an increase in the rate of compaction in an area. Increased levels of compaction from treading (treading of livestock) leads to decreases in pasture yields and is known to degrade the structure of soil and consequently its functions. Soil pugging (the combination of high stocking densities and rainfall) is also an effect of animal treading that impacts soil condition and yield – pastures are damaged by cows tearing up the paddock's soil structure. Soil pugging is much more commonly seen with cattle, due to their weight, in comparison to other livestock. Animal treading studies typically show high reductions in pasture yield, especially when soil is pugged; soil pugging also has a greater impact on soil condition, pasture productivity and yield than compaction alone.[963]

Reducing livestock density on-livestock farms is a widely practiced measure across Europe and further afield, with a range of direct benefits to environment and yield, depending on the livestock, system and location. Currently, however, headage payments to farmers under the CAP pay farmers per livestock unit, which rewards farmers for an increase in stocking numbers and consequently impacts compaction on soil. For some Member States, agri-environment schemes and other CAP-related incentives encourage farmers to reduce their stocking densities instead to promote biodiversity increases through new plant growth, improve soil condition, reduce compaction and erosion, and encourage better infiltration, which has other indirect environmental benefits.

12.7.2 Quantified Costs

Overview

There are various costs associated with reducing stocking density for farmers.

Firstly, the cost of managing additional silage (as an output of improved yield from lower treading) needs to be considered. In most pasture systems, pasture yield is used to create silage for winter feed for livestock. Silage is pasture grass that has been fermented in dark conditions, which preserves the pasture for livestock to eat during dry or winter months, when natural pasture is not good. The grasses are cut and then fermented to keep as much of the nutrients (such as sugars and proteins) as possible.

[963] Daniel, J.A., Potter, K., Altom, W.A.D.E.L.L., Aljoe, H.U.G.H. and Stevens, R.U.S.S.E.L.L., 2002. Long–term grazing density impacts on soil compaction. Transactions of the ASAE, 45(6), p.1911.

The nominal annual cost of establishing silage (from grassland pasture), assuming a 7-year sward life, is £120/pa for permanent grassland. The cost of sward improvement (maintenance of pasture and reestablishment of sward) ranges between £29/pa to £120/pa (over a 7-year period). The cost of making and storing silage depends on the method. Ensiled silage is created by storing silage in a silo, whereas baled silage is wrapped and stored in large, usually plastic wrapped, bales. The total cost for producing ensiled silage is £794/ha, with a cost of £132/t (DM). The total cost for producing baled silage is £935/ha, with a cost of £156/t (DM) and a cost of £30/bale.[964] These costs include establishment costs, annual variable costs, and annual production costs (such as fertiliser, mower, transport, fuel, and other expenses). It should be noted that silage is bulky to store and handle, and therefore storage costs can be high relative to its feed value. Storage facilities for silage are specialised and have limited alternative uses. Further, silage is costly to transport relative to its bulk and low density of energy and protein. As a result, transportation costs often limit the distance silage can be moved. While these costs are important to note, they were not included in the final estimation. Assuming that while there may be an increase in pasture yield from reduced stocking density, this may not correlate to a significant increase in silage production, as silage is produced by area.

Second, reducing stocking density across the EU would require livestock to be removed from grassland pastures. This would be done either through the sale of livestock, or movement of livestock to other areas or housing. As the price of livestock is highly variable and difficult to standardise for these quantifications, known costs associated with the away-wintering of livestock were used. The cost of keeping cattle away for 4 months during away-wintering, including providing silage and required labour, has an OPEX of £12/livestock unit (LU)/week, but reduces costs on farm by £2,390 pa,[965] indicating the cost of reducing stocking density.

The table below details the percentage yield improvements from removing dairy cattle from pasture for different time period from a selection of studies.

Table 12-26: The effects of animal treading on pasture productivity for treaded conditions from field trials in the literature on mixed ryegrass sward yield in different livestock (dairy cattle) systems from Drewry et al.

Management	Yield (DM) improvement from treaded to non-treaded pasture (%)	Interval	Stocking rate for treaded treatments
Dairy	-2%	1st Year	250-350 cows/ha for 8h
Dairy	6%	2nd Year	250-350 cows/ha for 8h
Dairy	9%	3rd Year	250-350 cows/ha for 8h
Dairy	12%	4th Year	250-350 cows/ha for 8h
Dairy 3h block grazing	10%	Oct-June	90-134 cows/ha for 3-12h
Dairy 12h block grazing	3%	Oct-June	70-90 cows/ha.day during lactation

964 https://www.fas.scot/downloads/farm-management-handbook-2022-23/

965 Wiltshire, J., Avis, K., Peters, E., Gill, D., Jenkins, B., 2022. Critical review of slurry and manure abatement possibilities, for the reduction and prevention of agricultural diffuse pollution emissions. Environment Agency.

According to EUROSTAT 48,865,000 ha of land in the EU-27 is classified as permanent grassland. Based on the assumption from Graves et al. that 38% of grassland is affected by compaction[966], it can be assumed that there is around 18,568,700 ha of compacted permanent grassland in EU. In 2016, average livestock density in the EU reached 0.8 livestock units per hectare of agricultural area.[967] Consequently, 14,854,960 livestock units (LUs) are estimated in the EU on average areas that are managed in areas of compacted grassland (noting that this assumes that: a) all compacted grassland is grazing land, and b) that this area of land continues to be grazed and hence has LUs that can be moved elsewhere). For comparison, in 2016 there were approximately 131 million LUs in the EU,[968] 49% of which were cattle; however, they are not all located on grassland areas. It is difficult to estimate the specific number of LUs in compacted grassland areas along for the whole EU.

At an OPEX of £12/LU/week, it would cost £178m/week for those livestock to be removed from compacted grassland. In order to achieve a yield improvement in the area of 3-10% (depending on management system and other variables), livestock would need to be removed from grassland for around 9 months, based on the data from the above table. This would cost in the region of €8.1bn for that 9 month period (currency rate December 2022).

12.7.3 Quantified Benefits

As noted above, reducing livestock density is a widely practiced measure with a range of direct benefits to environment and yield, depending on the livestock, system and location. Drewry et al.[969] reviewed a wide range of studies on animal treading and the associated effects on soil physical properties and pasture productivity from treading-induced soil compaction and pugging, providing key data on changes to yield resulting from changes to stocking density. The table above summarises the findings of the literature review, detailed the changes to ryegrass sward yield from different treading patterns and stocking density in non-pugged (dry) conditions. The results of the studies show that as stocking rates and treading intervals increase, there are decreases in pasture productivity.

Based on the European data base of soil properties, known as SPADE8, Schjønning et al. (2008)[970] estimated that 23% of the total agricultural area of Europe has a critically high level of compaction (for all agricultural systems). Graves et al. (2015)[971] estimated the total annual cost of soil compaction in England and Wales to £470 million per year, corresponding to €540 million per annum (pa) (currency rate January 2019). Hence, per hectare costs of soil compaction amount to approximately €140.2/ha/pa when related to the compaction-affected area, and about €56.4/ha/pa on the basis of the total agricultural area.[972] Based on the estimate that there is around 18.6m ha of compacted permanent grassland in EU, reducing the soil compaction would save an annual cost of €2.6bn pa.

[966] The total costs of soil degradation in England and Wales - ScienceDirect
[967] Agri-environmental indicator - livestock patterns - Statistics Explained (europa.eu)
[968] Agri environmental indicators Livestock patterns_Statistics .pdf (wallonie.be)
[969] https://openresearch-repository.anu.edu.au/bitstream/1885/35728/2/01_Drewry_Pasture_yield_and_soil_2008.pdf
[970] Driver-Pressure-State-Impact-Response (DPSIR) Analysis and Risk Assessment for Soil Compaction—A European Perspective - ScienceDirect
[971] The total costs of soil degradation in England and Wales - ScienceDirect
[972] EEA (2022) Soil monitoring in Europe Indicators and thresholds for soil quality assessments. https://www.eea.europa.eu/publications/soil-monitoring-in-europe-indicators-and-thresholds

The key benefit to reduced compaction is increased yield in grassland, and production of silage. The value of silage ranges between £47/t to £67/t (farm weight, or around £157 to £246/t DW), depending on the quality.[973] While silage can be sold to other farms, most likely close neighbours, there are few ready off-farm markets for silage in most areas. Moving silage from one silo to another is risky, especially for haylage. Therefore, when a crop is harvested as silage, the farmer is usually committed to feeding it to livestock. So, despite reduced stocking density enabling an increase in pasture yield and therefore silage, there is a low opportunity for farmers to profit off this increase. Pasture productivity and yield increases from reducing the stocking density, and therefore the cost of making silage may increase. However, as silage is used for feed during poor weather or winter, having greater stores of silage can be used in place of buying feed. Generally, grass silage accounts for 20-25% of total annual feed per cow on well-run dairy farms, and up to 30% of total feed on beef farms depending on the production systems in place.[974]

Grass yield can range from 1t dry matter (DM)/ha on hill ground to 20t DM/ha on good dairy land. Yield is highly variable: average grass yield is around 6t DM/ha on Scottish upland/lowland grazing livestock farms, for example. Grass growth varies greatly from year-to-year, farm-to-farm and field-to-field.[975] Compaction on grassland areas has been shown to reduce pasture yield by around 1-3% in some studies,[976] and up to 12% in others. Variation in changes to yield is highly dependent on the management system, soil type, location, weather, and livestock type and breed,

It should be noted that some studies[977] assume yield losses due to compaction of 8% for soils with >40% clay, and 4% for soils with 15–25% clay, while yield losses for lighter soils are negligible, which is certainly increased until today. However, actual data is missing for Europe even if for smaller regions very detailed data is available.

Taking the 18.6m ha of compacted grassland in the EU, assuming an average output of 6 tDM/ha, a yield change of between 3 – 10%, this produces an estimated value of increased silage output of between €600m to €2.7bn pa.

12.7.4 Summary

The table below summarises the key costs and benefits for reducing stocking density. The key costs included here are the removal of livestock from grassland areas in the EU affected by compaction for 9 months, while the benefit comes from the savings made on-farm during this period.

Table 12-27: Summary of the key quantified economic costs and benefits of using organic manure on soil

Impact category	Impacts on EU
Costs	< €8.1 billion (9 months) (not including on-farm savings)

[973] https://www.fas.scot/downloads/farm-management-handbook-2022-23/
[974] Quality Grass Silage - Teagasc | Agriculture and Food Development Authority
[975] *Ibid.*
[976] The total costs of soil degradation in England and Wales - ScienceDirect
[977] Eriksson, J., Håkansson, I. and Danfors, B., 1974. Jordpackning-markstruktur-gröda [The effect of soil compaction on soil structure and crop yields]. In Rep. 354 (pp. 1-82). Swedish Institute of Agricultural Engineering.

Benefits	€0.6bn to €2.7bn pa

This quantification focuses on livestock grazing systems. This does not include the costs associated with resolving compaction of soil in arable areas, which is a major issue in and of itself. The cost quantification considers the removal of livestock over a lengthy period of time, which for many farmers is not a feasible one. As noted above, yield changes in pasture are highly variable at the regional, farm, and field level and depend on a range of other factors, meaning that the yield improvements resulting from reducing stocking densities will likely not be expected at the same rates even on the same farm.

Table 12-28: Significant impacts for in-depth assessment and core indicators

13 SCREENING OF IMPACTS

Specific impact category	Broad impact category			Priority	*Rationale for the choice of priority level*
	Environmental	Social	Economic		
Climate	/	x	x	1-High	Soils are a major carbon stock and have a considerable capacity to store more carbon
Quality of natural resources (soil)	/	x	x	1-High	Purpose of the Soil Health Law is to maintain the health of healthy soils, restore the health of unhealthy soils and to remediate contaminated land, hence maintaining and restoring their capacity to provide ecosystem services
Biodiversity, including flora, fauna, ecosystems, and landscapes	/			1-High	Soils support terrestrial plants and hence the basis of all terrestrial trophic chains (including pollinators) - and constitute an ecosystem of their own
Public health & safety and health systems		/		1-High	Contaminated soils have an impact on public health via contamination of water, of crops or of air. The restoration of soil health can improve the quality of landscapes, forests and natural heritage, and hence improve quality of life and well-being of citizens.
Conduct of business			/	1-High	Soil management practices impact the costs and benefits of farming & foresting, in the short and the long term, and hence also the value of agricultural land and forests. Soil remediation impacts the cost of economic activities performed on a piece of land and the value of the land on which they are exerted.
Position of SMEs			/	1-High	Mandatory as part of the SME test
Public authorities (and budgets)			/	1-High	Sources of costs for public budgets at Member State level: monitoring of soil health; set-up and maintenance of register of contaminated sites; remediation of orphan sites
Sustainable development	/	/	/	1-High	A Soil Health Law would impact the following SDGs: 2 - Zero hunger; 6 - Clean water and sanitation; 12- Responsible production & consumption; 13- Climate action; 14 - Life below water; 15 - Life on land
Water supply infrastructure, treatment and consumption	/			1-High	Soils perform essential functions in the storage (and hence the regulation of flows) and purification of water
Inter-generational distribution of benefits, costs and risks		/	/	1-High	Soils are an essentially non-renewable resource, so that any irreversible deterioration performed today has consequences on all generations to come and hence negatively impacts intergenerational fairness.
The likelihood or scale of environmental risks	/		/	1-High	Sustainable soil management, reduced soil sealing reduce the likelihood and severity of floods and of droughts
Quality of natural resources (water, air etc.)	/	x	x	2-Medium	A better soil health will indirectly improve that of water, because of the purification function of healthy soils and the avoidance of contamination from soils, and of air, by avoiding the transport by wind of contaminated dust.
Education and training, education, and training systems		/	/	2-Medium	Some Sustainable Soil Management practices, and the underlying soil science, imply a rather deep paradigm change in agriculture and forestry, and hence require resources for the training institutions
Administrative burdens on business			/	2-Medium	Additional duties on businesses including landowners foreseen in SHL include: obtention of Soil Health Certificate or Soil Passport
Sectoral competitiveness, trade, and investment flows			/	2-Medium	Imported agricultural or forestry products will not be submitted to the same obligations as those grown in the EU
Efficient use of resources (renewable & non-renewable)	/		/	2-Medium	The Soil Health Law leads to a more sustainable use of two non-renewable resources: healthy soils (SSM) and arable surface (LATA)

Specific impact category	**Broad impact category**			**Priority**	***Rationale for the choice of priority level***
Employment		/	/	2-Medium	Impacts on farming and forestry businesses is anticipated to remain small enough to have any significant impact on their operation, and hence on employment. There may be a minor employment generation for trainers and other service providers on Sustainable Soil Management. A large employment creation (relative to the current size of the sector) is likely to arise for the remediation of contaminated sites and for the re-use of excavated soils
Territorial impacts (specific (types of) regions and sectors)	/	/	/	2-Medium	The share of EU soils that are considered as 'unhealthy' is in the range of 60%. The aspects of the Soil Health Law on unhealthy soils will thus have a very broad geographic distribution. The aspects of the Soil Health Law improving the resilience of soils, of water supply and of agriculture to climate change will selectively impact the regions of the EU most threatened by climate change. The aspects of the Soil Health Law on contaminated sites will have a concentrated effect on regions with a high number of legacy contaminated sites
Food safety, food security and nutrition	/	/	/	2-Medium	Sustainable Soil Management reduces vulnerability of food and water supply to weather hazards and reduces its dependency to non-renewable mineral resources (phosphates, natural gas)
Waste production, generation, and recycling	/	/	/	2-Medium	Excavated soils constitute a large fraction in volume of waste generated in Europe. The Soil Passport supports the re-use of excavated soils and hence reduces its disposal
Fundamental rights	/	/	/	2-Medium	The health of soils impacts the food security of future generations and hence their fundamental rights, in a perspective of inter-generational justice.
Land use	/		/	3-Low	The Soil Health Law leads to monitoring the environmental impacts of change in land use
Animal welfare	/			3-Low	Reduction in emissions of nitrates could stem from placing farm animals in closed housing, hence impacting their welfare
Culture		/		3-Low	The restoration of soil health can improve the cultural value of landscapes and natural heritage (forests, wetlands...)
Functioning of the internal market and competition			/	3-Low	The existing national legislations on soil management do not impose mandatory additional costs to farming or forestry businesses, and hence do not impact the functioning of the Internal Market
Sustainable consumption and production	/		/	3-Low	Sustainable Soil Management practices will make agriculture and forestry products environmentally sustainable. Included in the 'sustainable development' criterion
Income distribution, social protection, and social inclusion (of particular groups)		/	/	3-Low	Increased costs for farmers or foresters are likely to be transmitted to customers, provided external competition is not too intense.
Technological development / digital economy		/	/	3-Low	Large-scale requirements on monitoring and on soil remediation can create a market for innovative technologies, including digital technologies. The Soil Passport is likely to be digital, and create a new technology in line with the Digital Product Passport considered for industrial products
Consumers and households		/	/	3-Low	The additional costs of food or forestry products due to more sustainable soil management practices is likely to have a limited impact on the food budget of households and consumers.
Property rights; intellectual property rights		/	/	3-Low	Obligations set on land owners on sustainable soil management practices will affect the exercise of their property rights.
Innovation (productivity and resource efficiency); research (academic and industrial)	/	/	/	3-Low	Areas of potential innovation and research activities related to a Soil Health Law include: soil health measurement and monitoring techniques, remote sensing of soil health, adaptation of sustainable soil management practices to soil type and climate, remediation of contaminated sites, re-use of excavated soil
Transport and the use of energy	/	/	/	3-Low	"Better soil management reduces erosion, and hence the transport of sediments impeding the operation of inland waterways and of harbours
Third countries, developing countries, and international relations	/	/	/	3-Low	The import of farming or forestry products into the EU is likely to have a cost advantage compared to EU producers because of the additional obligations set on these
Capital movements; financial markets; stability of the euro		/	/	3-Low	The remediation obligations on contaminated land may have a negative impact on its value, and hence impact the balance sheets of financial institutions owning this land or having lent to the impacted landowners using this piece of land as collateral.
Fraud, crime, terrorism, and security, including hybrid threats	/	/	/	3-Low	Increased soil monitoring may lead to detect violations of environmental regulations (illegal landfills, illegal land take)

14 EXAMPLE SSM AND RESTORATION PRACTICES

The following tables include initial, illustrative lists of examples of practices which could be defined as either sustainable soil management (SSM) practices, harmful practices, or broader soil restoration practices. Note: these lists do not represent a complete catalogue of practices in each case and are intended to be illustrative examples based on the research conducted under this impact assessment. Furthermore, in some cases, certain practices might be defined as sustainable or restorative, but in other situations the same practices could be harmful – their impact will depend on the specific context in which they may be implemented.

Table 14-1: Illustrative list of examples of SSM practices

	Sector			Indicator						
Intervention	**Agriculture**	**Forestry**	**Urban**	**Erosion**	**Compaction**	**Biodiversity loss**	**Loss of organic matter**	**Nutrient loss**	**Salinisation**	**Contamination**
Soil nutrient testing for optimised fertiliser management	x							x		
Immediate incorporation of slurry after application	x							x		
Restrict use of slurries and manure with high readily available N to periods of active crop growths	x							x		
Restrict/prohibit application of manures and fertilisers close to watercourses	x							x		
Avoid turning permanent grassland/woodland/forest land into arable use	x	x	X			x	x	x		
Match nitrogen and phosphorus contents of livestock diets to livestock need	x							x		
Utilisation of nutrient management plans	x	x	x					x		
Utilisation of crop protection management plan	x					x				x
Utilisation of effective pesticides with minimal environmental impact	x	x	x			x				x

	Sector			Indicator						
Intervention	Agriculture	Forestry	Urban	Erosion	Compaction	Biodiversity loss	Loss of organic matter	Nutrient loss	Salinisation	Contamination
Utilisation of soil management plan	x	x	x	x	x	x	x	x		
Utilisation of wind breaks	x			x						
Utilisation of nurse crops	x			x						
Maintain high water level on cropped or arable land on peat soils	x						x			
Protection of wetlands	x	x	X			x	x			
Utilisation of cover crops	x	X		x	x	x	x	x		
Restriction of fertiliser application to crop needs	x							x		
Restriction of manure application to crop needs	x							x		
Restricted use of pesticides to crop needs and risk forecasting	x					x				x
Integrated pest (disease, weed) management	x	x	x			x				x
Enforcement of buffer zones	x					x		x		x
Restrict areas of monoculture	x					x				
Sustainable production of biofuels	x			x	x	x	x	x		
Utilisation of agroforestry	x	x		x	x	x	x	x		
Reforestation/Tree establishment/ or farm woodland		x	x	x		x				
Biodiversity protection	x	x	x			x				
Habitat protection	x	x	x			x				
Maintain soil vegetative cover	x			x	x	x	x	x		
Utilisation of controlled traffic farming	x			x	x	x	x	x		
Utilisation of reduced tillage farming	x			x	x	x	x	x		
Inclusion of legumes in rotation	x				x	x		x		
Inclusion of grass leys in rotation	x				x	x		x		
Reduction/prohibition of drainage of peatlands	x	x				x				

	Sector			Indicator						
Intervention	Agriculture	Forestry	Urban	Erosion	Compaction	Biodiversity loss	Loss of organic matter	Nutrient loss	Salinisation	Contamination
Incorporation of plant residues/green manure	x					x	x			
Contour farming in slopes	x			x			x	x		
Conversion to grassland	x	x	x	x		x	x	x		
Application of organic matter or manure	x	x	x		x	x	x	x		
Chopping and leaving (or incorporating) straw	x					x	x			
Utilisation of in-field grass strips	x					x	x	x		
Promotion of use of vehicles and machinery adjusted to soil strength (tyre pressure control systems)	x	x	x	x	x					
Establishing stone walls/terraces on slopes	x		x	x				x		
Reducing stocking density and fertiliser inputs on improved grassland	x			x	x			x		
Seasonal livestock removal on intensive grassland	x			x	x			x		
Livestock management should take into account grazing intensity and timing, animal types and stocking rates	x			x	x			x		
Natural soil recovery through resting the field (area closure)	x					x	x			
Use of forest harvesting methods which do not harm the soil or the stand		x		x	x	x	x			
Continuous forest cover to protect soil productivity		x		x		x	x			
Selected tree felling		x		x	x	x	x			
Avoidance of clear-felling		x		x	x	x	x			
Application of nitrification inhibitors	x							x		
Utilisation of 'natural' (green) drainage systems	X	X	X	X				X		
Utilisation of artificial (grey) drainage systems	x	x	x	x				x		

	Sector			Indicator						
Intervention	**Agriculture**	**Forestry**	**Urban**	**Erosion**	**Compaction**	**Biodiversity loss**	**Loss of organic matter**	**Nutrient loss**	**Salinisation**	**Contamination**
Use of intercropping	x			x		x	x	x		
Use of strip cropping	x			x		x	x	x		
Utilisation of slow and controlled release fertilisers	x	x						x		
Optimisation of fertiliser application method, types, rates and timings	x	x						x		
Utilisation of soil and plant tissue testing to optimise fertiliser inputs	x							x		
Optimise surface cover to minimise evaporation losses	x								x	
Improvement of irrigation water use efficiency by improved conveyance, distribution of field application methods	x		x						x	
Optimise irrigation management to ensure sufficient water for plant growth and efficient drainage	x								x	
Utilise water desalinisation when appropriate	x								x	
Installation of surface and subsurface drainage systems	x		x						x	
Promote monitoring programs for soil biodiversity, including biological indicators	x	x				x				
Utilisation of water reuse	x	x	x						x	
Sustainable use of soils in urban planning			x		x					x

Table 14-2: Illustrative list of examples of harmful practices

	Sector	Indicators

Intervention	Agriculture	Forestry	Urban	Erosion	Compaction	Biodiversity loss	Loss of organic matter	Nutrient loss	Salinisation	Contamination
Application of slurries and manure with high readily available N in periods without active crop growths	x							x		
Application of manures and fertilisers close to watercourses	x							x		
Conversion of permanent grassland into arable use	x					x	x	x		
Large areas of monoculture	x		x			x				
Use of heavy machinery under wet conditions	x	x	x		x					
High stocking density and fertiliser inputs on grassland adjacent to a watercourse	x			x	x			x		
Clear-felling		x		x	x	x	x			
Extraction and landfilling			x	x		x	x	x		
Sealing	x	x	x			x	x	x		
Contamination	x		x							x

Table 14-3: Illustrative list of examples of restoration practices

	Sector			Indicators						
Intervention	Agriculture	Forestry	Urban	Erosion	Compaction	Biodiversity loss	Loss of organic matter	Nutrient loss	Salinisation	Contamination
Utilisation of sub-soiling	x	x	x		x					
Maintain high water level on cropped or arable land on peat soils	x	x	x	x		x	x			
Restoration of wetlands	x	x	x			x	x			
Reforestation		x	x	x		x	x			
Incorporation of plant residues/green manure	x		x			x	x			
Conversion to grassland	x		x	x		x	x			
Application of organic matter or manure	x					x	x			
Chopping and leaving (or incorporating) straw/residues	x	x	x		x	x	x			
Natural soil recovery through resting the field (area closure)	x		x	x	x	x	x	x		
Utilisation of techniques for reclamation of saline soils	x								x	

15 QUANTIFICATION OF EMPLOYMENT IMPACTS

15.1 Introduction

Different options under the SHL package imply different levels of investment in goods and services in the future, and hence will also have employment impacts. The underlying mechanism of these impacts is that for each policy option, the required investment implies a need for additional production of certain goods and services and as a consequence, an increase in the labour demand of the corresponding sector(s). This analysis considers two types of impacts on employment:

- **Direct impacts**, that is, additional employment in the sector(s) that would be needed to increase their output to produce additional goods and services.
- **Total impacts,** which reflect the economy-wide effects on employment caused by the changes in investment. Total impacts include:
- **Direct impacts:** the changes in employment in the sectors that change their production,
- **Indirect impacts:** changes in employment in their suppliers, suppliers of the suppliers, etc., due to the additional demand driven by the increased output in sector(s),
- **Induced impacts:** the economy-wide employment effects caused by the additional employees spending their wages on goods and services.

To quantify these employment impacts, an Input-Output methodology was used, which means rely is put on Input-Output (IO) tables and annual wage data published by Eurostat. IO tables give statistics for each economic sector on the amount of goods and services they have bought from every economic sector as inputs and what their output was in a given year.

Quantitative employment effects have only been estimated for those investments and costs for which quantitative estimates have been made. This may not capture all employment effects associated with the SHL package, i.e. where costs for certain activities have not been estimated. That said, cost estimates for all key components of the SHL package have been estimated, hence the estimates of job impacts are deemed to be fairly comprehensive.

15.2 Direct impacts

Direct impacts are calculated for each option separately according to the following formula:

New FTE/ year = Inv / year * Share_domestic * Share_labour / Average_salary,

Where:

- *New FTE/ year* is the expected direct impact on employment;
- *Inv/year* – yearly investment corresponding to this NACE code activity;
- *Share_domestic* reflects the assumption on how much of these goods and services will be produced domestically;
- *Share_labour* reflect the share of output designated to wages and salaries for this activity; and
- *Average_salary* shows the average payment per FTE in the industry.

Step1: Identify proportion of costs that reflect labours' share

Costs have been estimated for several of the building blocks under the SHL package, but not all. Quantitative costs have been appraised for: expanding the soil health monitoring network, investigation of contaminated sites, remediation of contaminated sites, and other administrative burden. Furthermore, illustrative costs have been developed for a sample of sustainable soil management (SSM) practices to demonstrate the potential magnitude of costs should practices be implemented at EU-level. As noted elsewhere in the report, these cost estimates carry a number of important caveats, including:

- estimates of costs for investigating and remediating contaminated sites are very uncertain (represented by the wide range) and do not exclude activities which would otherwise be expected under the baseline, and
- estimates of costs for SSM do not represent the true cost should the option be implemented in practice – this will depend on the precise basket of practices implemented in each Member State. Instead these estimates seek to illustrate the potential magnitude of costs should certain or a selection of measures be implemented EU-wide, and have been estimated using a simple extrapolation.

For those that have been quantified, given the underlying data there is some uncertainty around labours' share (i.e. the proportion of costs which are spent on workers' salaries, which will simulate any increase in employment). An assessment of the proportion of costs that are labour and a working assumption for each option are presented in the following table.

Note, only 3 of the 5 illustrative SSM measures are carried forward for assessment of employment effects. As shown in the table below, for two measures (reduced tillage and crop rotation) the nature of the costs of these measures suggests that the attribution of costs to labour would be negligible. For reduced tillage, the costs represent a reduction in crop yield, and in fact a reduction in labour costs is captured as part of the benefits of this measure. For crop rotation, the costs represent increases in variable and machinery cost, and again the benefits of this measure include very small labour savings.

Table 15-1: Costs associated with each option and labours' share

Building block	Sub-measure	Cost EURm pa	Cost EURm pa	Cost description	Assumed % labour
		Low	High		
Monitoring	n/a	42	42	Mix of labour and other costs. Labour for sampling EUR100 (vs. materials EUR150). Majority is laboratory costs, which will again be a mix of labour and other (e.g. energy / materials)	50%
CS investigation	n/a	1,600	1,600	Survey, site investigation. Likely to include some laboratory testing costs, and materials (e.g. travel to site)	80%
CS remediation	n/a	823	823	Likely to cover a range of costs - some labour (e.g. organisation of remediation / planning / monitoring / etc., and labour involvement in remediation), but also other costs (e.g. cost of remediation techniques, capex, opex, materials).	33%
Other admin	n/a	7.0	7.0	Most associated with ongoing monitoring of land take; majority potentially labour	80%
SSM	Cover crops	2800	2800	Cost of the cover crop seed and the extra operations associated with the planting, managing and defoliating a cover crop; at least 20% is seed	80%
	Reduced tillage	13000	13000	Costs are reduced yield; in fact, part of the benefits estimation is a reduction in labour costs - around 13% of benefit is labour reduction	0%
	Crop rotation	120	120	Costs represent increase in variable and machinery cost. Benefits include very small labour saving	0%
	Organic manures	1500	10500	Costs represent installation of storage (some of which will be labour, but an uncertain amount) plus spreading (all labour). Spreading represents ~25-30% total costs	30%

	Stocking density	8100	8100	Cost of keeping cattle away for 4 months during away-wintering, including providing silage and required labour; but this also provides a labour saving on farm	50%

Step 2: Selection of NACE code sector

This step selects the relevant NACE code sector for which wage and multipliers are selected. It is challenging to perfectly map the activity under the different building blocks to a NACE code sector. The assumed sector adopted is presented in the following table, alongside the implied average income per FTE per year (or income per Annual Work Unit (AWU) for agricultural activities).

Table 15-2: Assumed NACE sector and average income

Building block	Sub-measure	NACE code	NACE Code sector description	Average wage per annum per FTE (EUR pa) (*Average income per AWU)
Monitoring	n/a	M72.1	Research and experimental development on natural sciences and engineering	59,200
CS Investigation	n/a	M72.1	Research and experimental development on natural sciences and engineering	59,200
CS remediation	n/a	E39	Remediation activities and other waste management services	40,000
Other admin	n/a	J62.0	Computer programming, consultancy and related activities	61,300
SSM	Cover crops	A1.1	Growing of non-perennial crops	22,500*
	Reduced tillage	-	-	-
	Crop rotation	-	-	-
	Organic manures	A1.1	Growing of non-perennial crops	22,500*
	Stocking density	A1.4	Animal production	22,500*

Note: '-' denotes where no job impacts have been calculated

Step 3: Share of domestic production

Step 3 considers what proportion of the costs (and employment benefit) will accrue to domestic (i.e. within the EU-27), and what may be spent on imports of products or services. There is uncertainty around the proportion of labour share that would be domestic. That said, many of the costs are associated with activities that occur within the EU-27 – e.g. monitoring on EU sampling sites, remediation of CS within the EU-27, sustainable soil management measures implemented on agricultural, forestry or urban soils within the EU-27. Hence working assumption is that 100% of the services would be provided by EU-27 based labour.

Step 4 – Estimates of direct employment impacts

Bringing together the steps above, the table below presents the estimates of the employment impacts associated with the options assessed under the SHL package.

Table 15-3: Direct employment effects

Building block	Sub-measure	Employment impact (low – high, FTEs/AWUs)
Monitoring	n/a	360 FTEs on an ongoing basis
CS Investigation	n/a	26,200 FTEs over 15 years (assumed implementation period for investigation)*
CS remediation	n/a	8,200 FTEs over 25 years (assumed implementation period for investigation)*

Other admin	n/a	90 FTEs on an ongoing basis
*SSM***	*Cover crops*	*100,000 AWUs on an ongoing basis*
	Organic manures	*20,000 to 140,000 AWUs on an ongoing basis*
	Stocking density	*180,000 AWUs on an ongoing basis*
TOTAL		**35,000 FTEs on an ongoing basis (over first ~20 years)** ***(300,000 to 420,000 AWUs on an ongoing basis)***

Note: '' estimates are not additional to baseline (i.e. likely to capture employment impacts associated with activities which are otherwise expected to occur in the absence of the implementation of SHL); '**' estimates are based on simplistic extrapolation of sample of SSM to EU-27 wide level, and hence are very uncertain*

Several key conclusions can be drawn:

- The estimate of employment effects is very uncertain, in part driven by uncertainty in the underlying quantification of costs associated with different options under the SHL package.
- It is estimated that the ***SHL package could have an associated employment effect of 35,000 FTEs on an ongoing basis over the first ~20 years***.
  - In addition, there will be significant employment effects associated with the implementation of SSM and restoration practices. Estimating these effects carries even higher uncertainty. Illustrative costs have been estimated for a sample of practices applying a simplistic extrapolation to EU level - it is estimated ***that 300,000 to 420,000 annual working units (AWUs) could be created associated with implementation of three SSM practices EU-wide on an ongoing basis***.
- These estimates do not capture all employment impacts associated with the SHL package. It has not been possible to comprehensively estimate the costs of some options under the SHL package (i.e. SSM and restoration activities), hence employment impacts could not be comprehensively assessed.
  - As noted above, illustrative cost estimates were developed for a sample of 5 SSM practices, but which practices will be actually implemented and to what extent and in which Member State is uncertain at this stage. This does not capture employment effects associated with any SSM or restoration practices implemented in forest or urban soils, and employment effects could be greater where more intensive efforts are required to restore soils or adhere to a wider range of SSM practices.
  - Furthermore, some practices may have a negative impact on employment which is not captured here. For example, two of the sample of SSM practices assessed could have a negative impact: reduced tillage will reduce the demand for labour on farm; crop rotation, in the case study assessed, could also have a negative (but much smaller) impact on labour demand.
- Estimation of employment effects of investigation and remediation of contaminated sites is also challenging. Estimation is highly uncertain given the high uncertainty in the underlying estimation of costs for both activities. In turn, this reflects uncertainty around the estimation of the number of sites which may require investigation (and what type), and which sites require remediation (and which type). This uncertainty is illustrated by the wide uncertainty ranges around the quantitative estimates.
  - Furthermore, in both cases the quantification presents the total, absolute employment effects, and ***does not*** assess the impact of the option relative to the baseline. I.e. these estimates will likely capture employment impacts associated with activities which are otherwise expected to occur in the absence of the implementation of SHL package.

15.3 Total impacts (including indirect and induced)

Alongside direct employment effects, investment can have indirect and induced employment effects as the initial investment ripples through the economy. In this analysis, two approaches have been deployed to assess these impacts:

1. ***JRC jobs calculator:***[978] The calculator gives the total (direct + indirect + induced) economy-wide increase in jobs resulting from an increase in production of a certain sector. Total impacts are proportional to the direct impacts and already include them. That is, for years with higher direct impacts, also higher total impacts are observed.
2. ***Output multipliers:***[979] The total output multiplier for a given NACE sector can be aggregated from the individual sector-specific effects in Eurostat's output multiplier tables. Although defined for output, these can be applied to employment to define an illustrative impact of these effects.

Both approaches have pros and cons – the JRC jobs calculator includes both indirect and induced effects, whereas the Output Multipliers only captures indirect effects. Furthermore, there is greater uncertainty around the application of Output Multipliers to agriculture sectors and the interpretation of resulting downstream employment effects. However, the JRC calculator only includes multipliers for a defined number of aggregated industry categories which are not directly mapped to NACE codes, hence selection and the relevance of a given multiplier is challenging. Estimation of the effects following each approach is presented in the following tables.

Table 15-4: Estimation of effects using JRC jobs calculator (Direct + Indirect + induced)

Building block	Sub-measure	Sensitivity	JRC Calculator sector selected*	Jobs created per EUR 1m invested	Total jobs created (FTEs – Direct + Indirect + induced)
Monitoring	n/a	n/a	Business services	22.71	480
CS Investigation	n/a	n/a	Business services	22.71	35,200
CS remediation	n/a	n/a	Water	24.56	8,100
Other admin	n/a	n/a	Communication	31.05	170
SSM	Cover crops	Low	Other cereals	25.45	57,000
		High	Fodder crops	70.35	158,000
	Organic manures	Low	Other cereals	25.45	11,500 to 80,200
		High	Fodder crops	70.35	31,700 to 221,600
	Stocking density	Low	Dairy products	26.81	108,600
		High	Bovine cattle	44.67	180,900

Notes: '' sector selected from pre-defined list on the basis of the closest description to the activity for which the cost is incurred.*

[978] Source: https://datam.jrc.ec.europa.eu/datam/mashup/JOBS_CALCULATOR/
[979] https://ec.europa.eu/eurostat/web/esa-supply-use-input-tables/data/database

Table 15-5: Estimation of effects using output multipliers (Direct + Indirect)

Building block	Sub-measure	NACE sector selected*	Euros generated per 1 Euro invested	Total jobs created (FTEs – Direct + Indirect)
Monitoring	n/a	Scientific research and development services	1.04	370
CS Investigation	n/a	Scientific research and development services	1.04	27,300
CS remediation	n/a	Sewerage services; sewage sludge; waste collection, treatment and disposal services; materials recovery services; remediation services and other waste management services	2.06	17,000
Other admin	n/a	Computer programming, consultancy and related services; Information services	2.78	250
SSM	Cover crops	Products of agriculture, hunting and related services	1.74	173,000
	Organic manures	Products of agriculture, hunting and related services	1.74	34,800 to 243,600
	Stocking density	Products of agriculture, hunting and related services	1.74	313,200

As can be seen from the tables, estimating indirect and induced effects is uncertain and is somewhat dependent on the method chosen. For example, using the JRC jobs tables, for CS remediation the estimated total job effects (direct + indirect + induced) is similar to the estimates of the direct effects alone (estimated in the section above). This is to a certain extent driven by the selection of the relevant sector in the JRC tool: 'water' is selected as the closest potential category as it is assumed that also captures waste management activities, which in turn contains the NACE code including remediation actions adopted in the estimation of direct effects). Likewise, the choice of agriculture sub-sector greatly affects the size of the estimated effects. In the JRC calculator, many disaggregated agriculture sectors are available, several of which may be applicable to the options at hand. This is illustrated in the low and high estimates in the JRC calculator results table.

The JRC calculator is generally preferred as it captures all three types of impacts. However, it is important to note that the additional granularity of the sector-split available in the JRC calculator drives additional complexity in the approach. Furthermore, it is uncertain to what extent 'jobs' from the JRC calculator can be readily applied to extrapolate estimates of agriculture employment effects estimated in terms of AWUs, and how this translates into employment effects into other sectors.

On the basis of the JRC Calculator outputs:

- o The total employment effects of the SHL package could fall around 44,100 FTEs on an ongoing basis. In addition, there could up to a further 560,000 agriculture AWUs associated with implementing the three, illustrative SSM practices on the basis of a simple, EU-wide extrapolation.
- Estimating direct and total jobs associated with the SHL package carries many uncertainties. There is greater confidence in the estimation of direct employment effects, relative to the indirect and induced effects included in the 'total' estimated effects.
- However it is clear that:
  - o Some of the activities carry a potentially significant employment benefit, including CS investigation and remediation.
  - o The largest employment benefit is likely to come through the implementation of restoration and SSM practices, many of which will require significant

labour input to the ongoing management of agricultural, forest and urban soils.

- Alongside the direct effects, there may be important and significant indirect (and induced) employment effects which provide an additional benefit to implementing the SHL package.

ANNEX 10: HOW DO THE OPTIONS COMPARE?

1 ANALYSIS OF OPTIONS UNDER SOIL HEALTH SOIL DISTRICTS (SHSD)

1.1 Description of the options

The building block will describe biological, physical, and chemical status of soil by defining parameters that define soil health. To do so, it is necessary to consider all key types of soil degradation and ensure that each is reflected in a single indicator or 'descriptor', and to define a metric or range around each descriptor which defines the boundaries of good health (e.g. soil organic carbon content may have a band of values, depending on pedoclimatic conditions that are considered good health). The assessment of soil health will be measured by soil samples taken in the field, taking a sufficient number of samples to be able to extrapolate from point assessment to area assessment with a sufficient level of statistical assurance. The assessment of soil health in an area is best done if this area has characteristics of homogeneity in terms of soil type and composition, climatic conditions and land use, hence areas (or 'districts') will be established in which representative soil samples and analysis are taken and classified as either healthy or unhealthy (achieving a compromise between cost and granularity given the great variability in soils across the EU). Soils District Authorities will be appointed with responsibility regarding the setting up and follow up of the relevant processes as soil health is best monitored and actions to achieve good health best designed at local level.

All options under this building block contain that: a) the EU will define a minimum list of soil health descriptors, b) an obligation is placed on Member States to establish soil districts, . Options 2, 3 and 4 then differ as follows:

- ***Option 2:*** soil district establishment is left wholly to Member States without common criteria; the development of soil health ranges is left to Member States.
- ***Option 3:*** soil district establishment is left to Member States following a set of mandatory common criteria defined by the EU; soil health ranges are developed by the EU for a selected set of parameters, based on available scientific knowledge.
- ***Option 4:*** soil district establishment is fully defined at EU level, and common soil health ranges are developed for all descriptors at EU level.

1.2 Discussion of the relative impacts, costs and benefits of the options

The establishment of soil health descriptors and districts across the EU are necessary facilitating steps to the subsequent implementation of effective soil health management and restoration actions. A set of chemical, physical and biological soil health descriptors must be established with threshold and/or range values to be able to classify which soils are 'healthy' and which soils are 'at risk'. This is a necessary prerequisite in order to identify, plan and implement a set of restoration measures which effectively achieve good soil health. In addition, the need to define, confirm and refine the ranges and thresholds for each soil health descriptor is expected to trigger investment in research, which would have an overall positive innovation effect, and also an additional benefit through the provision and use of information for further research and development, such as fertility and erosion studies, remote sensing analysis and ecosystem service assessments.

Although some indicators are currently monitored across different Member States and there are sets of indicators identified at EU level (e.g. through the LUCAS survey), there is no one set of criteria that have been developed and adopted, looking universally at soil health, for the purpose of achieving soil health (further details on existing descriptors and monitoring programmes can be found in Annex 9). As such, all SHSD options will achieve significant improvements in the information, data and governance of soil health relative to the baseline. However, it is anticipated that there will be some variance between the options on the basis of risk and costs.

The approach to defining soil health descriptors, the thresholds and ranges, and soil health districts will have a fundamental impact on the identification of which soils in the EU are deemed 'unhealthy', and hence which would be subject to restoration activity under the REST building block (and would be a focus for priority adoption of sustainable soil management practices under SSM). To explore this further, the EEA and JRC has undertaken analysis on the basis of the LUCAS 2018 survey to explore the areas of land which fall in different value thresholds relative to different soil health descriptors[980]. This, together with some evidence gathered from other sources (further detail is presented in an Information Box in Section 1.6.3 of Annex 9) is presented in the table below. It is important to note that analysis is not available against all soil health descriptors (e.g. topsoil compaction, loss of capacity for water retention, salinisation, soil biodiversity loss, etc).

Furthermore the analysis assesses all land against each descriptor individually and not in combination. Hence the areas of land assessed as 'unhealthy' against each indicator below are not directly additive to define a 'total land area that will be defined as unhealthy', as there could be some overlap (e.g. one parcel of land is deemed unhealthy against two or more indicators). Hence it is not possible to directly compare against the figures in the Annex I of Soil Mission report which suggest 60-70% of soil in the EU can be classed as degraded.

Table 1-1: Areas of land assessed as falling outside the working proposals for soil health descriptor ranges and thresholds (note: does not capture all descriptors on the proposed minimum list)

Soil Health Descriptor	Parameter ranges for soil health (working proposal)	Land area falling outside threshold or range (i.e. deemed unhealthy)
Loss of soil capacity for water retention	Threshold to be set by MS for each soil district, at a satisfactory level to mitigate the impact of extreme rain or drought, accounting as well for artificial areas (EU guidance to be developed)	*Not quantified*
Loss of carbon	For organic soils: respect EU targets at National level set by NRL and LULUCF (wetlands); For managed mineral soils: SOC/Clay ratio > 1/13; MS can apply a corrective factor where specific climatic conditions would justify it, taking into account the actual SOC content in permanent grasslands.	Threshold not quantified specifically, but: 52% of land deemed unhealthy based on more stringent SOC/clay ratio of 1/10. Majority of unhealthy classifications are observed in Member States characterised by a relatively warm climate such as the Mediterranean basin
Soil erosion and eroded soils	At district level: no eroded soils or unaddressed unsustainable erosion rate (>2 tonnes/hectare/year)	55m ha (arable, permanent crops, pastures and grassland across 27 Member States) or around 30% of all agricultural soil Area varies depending on threshold, and reduces to 25m ha (14%) or 14m ha (8%) under thresholds of >5 tonne/ha/yr and >11 tonne/ha/yr respectively.
Excess nutrients: phosphorous	<[30-50] ppm; MS to select the maximum threshold between the two values	Depending on the maximum threshold selected by Member States, anywhere between 11% to 52% of agricultural soils

[980] Trombetti et al. (2023). Report on soil quality mapping. European Topic Centre on Data Integration and Digitization. Draft version v09, Dec. 2022; final version available by Q2 2023

Soil Health Descriptor	Parameter ranges for soil health (working proposal)	Land area falling outside threshold or range (i.e. deemed unhealthy)
		could be deemed unhealthy (agricultural soil across 25 Member States) Area deemed unhealthy varies significantly where thresholds change: 1% and 99% agricultural soils would be deemed unhealthy under either a 70 or 6 mg/kg maximum limit respectively.
Salinisation	<4 dS m−1;	Threshold not quantified specifically, but: 3.8m ha in Europe are affected by salinisation, with the most affected regions being: Campania in Italy, the Ebro Valley in Spain, and the Great Alföld in Hungary, but also areas in Greece, Portugal, France, Slovakia and Austria[981].
Subsoil compaction	Sandy <1.8; Silty <1.65; Clayey <1.47; MS can replace this with equivalent parameter and range.	Threshold not quantified specifically, but: 23% agricultural land has critically high level of compaction 9.2% arable and 9% permanent crops fall within 'action value' for compaction (EEA)
Soil contamination	MS to achieve reasonable assurance that no unacceptable risk for human health and the environment exist	Threshold not quantified specifically, but: 23% and 18% of arable land (including pasture) exceeds a threshold for copper (Cu) and zinc (Zn) respectively, particularly in areas of intensive livestock
Excess nutrients: nitrogen	No ranges; just monitoring	Threshold not quantified specifically, but: relatively high N surpluses are found in intensive livestock regions, including: north-western Germany, the Netherlands, Belgium, Luxembourg, Brittany in France and the Po Valley in Italy.
Acidification	No ranges; just monitoring	Threshold not quantified specifically, but: 6.9% arable and 2.4% permanent crops have pH level that exceeds 'critical pH' for crop production
Soil biodiversity loss	No ranges; just- monitoring	*Not quantified*
Topsoil compaction	No ranges - monitoring	*Not quantified*
Separate assessment and monitoring		
Land take and soil sealing	(targets set voluntarily by MS)	Threshold not quantified specifically, but: net land take remains strongly positive, as ten times more land has been taken (approximately 12,000 km2 taken) than recultivated (1,200 km2 recultivated) between 2000 and 2018. Average absolute EU-27 area of soil sealed between 2006-2015 was approximately 332km^2 per year, reaching a cumulative area of 2,989km^2.

The key difference between the options is the level of flexibility, and how much is determined at either Member State or EU-wide level. Where possible, defining thresholds and districts at EU level minimises the risk of a lack of comparability and consistency across Member States. Based on the experience of legislation such as the Ambient Air Quality Directive (AAQD) and Water Framework Directives (WFD), leaving definitions of soil health and soil districts to Member States could result in a variance in the approach to and the thresholds and ranges defined for different descriptors, and also in the approach to defining districts. This would subsequently feed into different approaches to achieving soil health objectives (e.g. because different descriptors are chosen with different ranges). In particular under Option 2, and somewhat also Option 3, across Member States there may be a variance in the approach to defining thresholds different descriptors and the number of descriptors for which thresholds are

[981] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52006SC0620&from=EN

set (Indicator ‘Risks for implementation’: Option 2 ‘--‘), whereas Option 4 would remove this risk. This is significant for the SHL overall as what descriptors and thresholds are set will have a subsequent impact on the actions Member States may be obligated to take to restore or remediate unhealthy soils (link to REST and REM building blocks). For example, even where Member States allow for variance around land-use type in setting thresholds, how land-use is defined by Member States (and variation therewithin) could drive a difference in stringency between Member States – for example, if instead of broad 'agriculture' category, a Member State say adopts a more granular 'intensively used cropland' category, the threshold values for the soil districts involved may be set in a way that minimises effort required from land owners and managers by defining the intensively used land with comparatively low levels of ambition.

This risk also extends to the definition of soil health districts. Establishing soil health districts on the basis of pedo-climatic conditions and land use would require relatively more time and effort. As such there is a risk that there will be a lack of true representation of soils when Member States determine the soil districts, as some may choose a simpler method to set soil districts rather than determining a number of districts which represent the differences in soil type, climate, land use etc. within each Member State.

Greater harmonisation also somewhat mitigates the implementation risks of this building block - defining soil health descriptors is a technically complex area and not all Member States may have ready access to the necessary expertise needed to effectively define descriptors and thresholds. Stakeholders highlighted that expert knowledge surrounding the physical and biological aspects of soil health is not widespread, and that constant research, development and communication with experts is required to harmonise the understanding and reporting of the soil health indicators.

What is considered as healthy soil or not can vary significantly depending on a range of location-specific parameters. Soil health descriptor thresholds and/or range values must be determined taking into consideration the differences in climatic condition, soil type and land use (reiterated by expert stakeholders). Hence to define a set of soil health descriptors and thresholds that are applicable EU-wide and relevant to all soil districts is a challenging undertaking. Where this activity is undertaken by the EC under Option 4, there is a risk that either: a set of thresholds is produced which may not be optimal for all location-specific parameters across the EU (which could then drive SSM and restoration practices that are not optimally targeted, and could in some cases be detrimental); the descriptors and thresholds that are developed are too high-level and lack the granularity or ambition required to drive effective improvement action; and/or the process to develop a complete, robust set of thresholds is prolonged, having a detrimental impact on the timeframe for implementation of the legislation and the achievability of the time-bound targets set in the Soil Strategy. This is a significant risk associated with Option 4 (Indicator ‘Risks for implementation’: Option 4 ‘---‘). In between Option 2 and 4, Option 3 defines soil health ranges for a selected set of parameters, based on available scientific knowledge that already takes into account the variability of soil condition. The ranges selected are those for which an out-of-range value would mean a critical loss of ecosystem services. This reduces the risk of variability relative to Option 2, and also technical feasibility risks under Option 4 (Indicator ‘Risks to implementation’: Option 3 ‘-‘).

The assessment of soil health in an area is best done (lower costs and higher statistical assurance) if this area has characteristics of homogeneity in terms of soil type and composition, climatic conditions and land use. Where setting districts is left solely to Member States there is a risk that these could be set on an inconsistent basis across Member States and/or on a basis which is not optimal for defining soil health. For example, it would be simpler (and involve less administrative burden) to set districts on the basis of administrative units, rather than on, for example, pedo-climatic conditions, land capability and land use, but doing so would be counter-productive to the ability to effectively identify (and then take action to restore) unhealthy soils. However, again defining districts taking into account pedo-climatic conditions may be quite complex: climatic conditions may vary significantly over short distances, especially in mountainous areas; soil data may not be granular enough to draw clear boundaries, and different soil types may coexist at very close distance, especially in regions with heterogeneous soil types; and changing (climatic) conditions may give rise to the need to revisit SHSD boundaries over time. The provision of EU-wide mandatory criteria but maintaining some flexibility for Member States under Option 3 offers pragmatism but also improves the likelihood of understanding of these challenges in the definition of districts. The eventual number of districts defined is uncertain at this stage. Given the great variability of soils in the EU, a compromise will need to be found between homogeneity of soil condition in a district and a manageable number of soil districts. As an example, a plot level is far too small, while a country is in general far too big. A working illustration is that the number of districts could be in the range between the number of EU regions and provinces (i.e. between 242 to 1,166).

Together, these risks are anticipated to have a subsequent effect on the extent to which the options achieve the objective of improving information, data and governance around soil health, hence Options 2 and 4 is anticipated to be less beneficial in this respect compared to Option 3 (Indicators ‘Information, data and common governance on soil health and management’ and ‘Benefits’: Options 2 and 4 ‘++’; Option 3 ‘+++’).

Differences in subsidiarity are also anticipated to have an influence on administrative burdens. Where descriptors and districts are defined to a greater extent at EU-level (as under Option 3, and more so Option 4), in theory there could be a greater consolidation in activities and a smaller, overall upfront administrative burden. That said, under Option 4 as highlighted above, defining all thresholds at EU level could be very complex, which risks a protracted process – in this case there could be an upfront and ongoing administrative burden, producing the largest total administrative burden of all three options (given the uncertainty in this effect, this has not been captured in the quantification of costs below). All options present low administrative burden when comparing across the building blocks – Indicator ‘Administrative Burdens’: Options 2/3/4 ‘-‘). There is also some uncertainty around the additionality of this burden - there is already a budget of €12million within the Soil Mission dedicated to soil health definition which has the potential to reduce the administrative costs.

Administrative costs associated with the initial set up and recurring functions of the Soil District Authorities have been considered in the assessment. Costs associated with initially defining the Authorities are included alongside other costs (e.g. defining the soil districts themselves) in the upfront administrative burden of options under SHSD. In terms of the recurring functions of the Authorities (in their role as being responsible to achieve healthy soils), these are captured under the other building blocks which also consider the activities required to achieve healthy soils (e.g. their oversight of soil monitoring is captured under MON). There is some uncertainty around the additional burden of appointing Authorities and their ongoing activities as some of their role will be filled by existing staff. Where the separate administrative burden of each activity was estimated, at the same time how far such burden would be additional to existing resources was considered where possible. It was envisaged that there would be some co-ordination and economies of scale, at least between Authorities in the same Member State. Also, it is envisaged unlikely that the responsible Authorities would be completely separate entities for each soil district.

Table 1-2: SHSD Option administrative burdens (EC = European Commission, MS = Member States; no administrative burden for any other actors – e.g. businesses nor citizens – has been identified) – further information on the method to calculating administrative burden for any other actors – e.g. businesses nor citizens – has been identified) – further information on the method to calculating administrative burdens can be found in annex 9 section 6

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 2	8,100	-	330,000	-	330,000	-
Option 3	12,000	-	370,000	-	380,000	-
Option 4	66,000	-	27,000	-	93,000	-

Some Member States have already begun to take action to define soil health descriptors. Furthermore, there will be a varying number of districts across Member States. For Member States which have started to define descriptors or have fewer districts, the administrative burden of defining a complete set of descriptors under Option 2 may be less than for other Member States. Where the burden of developing the descriptors is instead placed on the EC, this reduces the burden (and the difference in burden) that falls across Member States (Indicator 'Distribution of costs and benefits: Options 2 and 3 '-', Option 4 '0'). Furthermore, through its critical role in facilitating action and measures to achieve soils in good health, this plays a key role in delivering inter-generational equity, avoiding a greater burden on future generations through the further deterioration of soil health. Otherwise, there is no significant driver of a differential impact between different stakeholders and stakeholder types – e.g. between rural and urban areas.

Defining descriptors and districts themselves will not have a direct impact on soil health (Indicators 'Impacts on soil health' and 'transition to sustainable soil management': Options 2/3/4 (+)). Likewise these options will not carry with them an adjustment cost (Indicator: Options 2/3/4 '0'). That said, as noted above, there is a strong link between this building block and those which will place an obligation on Member States to use soils sustainably (SSM) and restore soils to good health (REST) – defining soil health descriptors, thresholds and districts is a critical facilitating step necessary to determine the action and measures needed to achieve soils in good health, and hence improve soils and the surrounding environment. Hence how soil health descriptors and districts are defined will be one of a number of variables that will drive the actions taken under these building blocks, their costs and benefits.

Options 3 and 4 are considered marginally more consistent with all options under the other building blocks – for example, Option 2 where Member States define thresholds and districts is likely to be inconsistent with Option 4 under SSM or REST, where a set of measures to maintain or restore soil health is defined at EU-level. The same is somewhat true where Option 4 under SHSD is combined with Option 2 under SSM and REST, however even where soil health descriptors are defined at EU-level, it is perhaps not as inconsistent that a programme of measures that includes restoration measures could be defined by Member States (Indicator ‘coherence’: Option 2 ‘+/-‘, Options 3 and 4 ‘+’).

1.3 Summary of stakeholder views

The majority of stakeholders recognise the value in defining soil health descriptors and thresholds: several highlighted the benefit that these would play in triggering action as soon as a threshold or range is crossed. Stakeholders agreed that a number of different chemical, physical, water-related and biological indicators would be either reasonably or very effective to assess soil health, agreeing that a combination of indicators is required to do so effectively. In particular, several stakeholders highlighted the importance of reflecting ecosystem services and biodiversity, given their importance in addressing the functioning of soils and its services and the minimum levels required to maintain these services. With respect to the spatial level at which Member States should be required to assess and monitor soil health, responses to the OPC were very mixed – the most frequent response was ‘national’ level (20%), followed by ‘regional’ (19%) and ‘local’ (15%) administrative level. That said, it is notable that options ‘At the level of a zone homogeneous for pedo-climatic conditions and use’ and ‘At the level of a zone homogeneous for pedo-climatic conditions (whatever the land use)’ together formed the most common response (14% and 8% respectively, together comprising 22%).

Through stakeholder engagement, experts confirmed the link between the definition of descriptors for soil health and the obligations to achieve good soil health, namely that the ‘ranges will define the ambition and the amount of work to be done to restore soil health’.

Between the options, stakeholders noted that there would be a significant administrative burden under Option 2 associated with the research each Member State would need to individually undertake to define thresholds, and also that there is a lack of knowledge surrounding the physical and biological aspects of soil health at Member State level. A strong opinion across several stakeholders was that it would be important to set soil districts by natural borders to effectively determine soil health and any restorative action to undertake: geology (and soil types), climate, land use / land cover, and chemical contamination if needed. Stakeholders also noted that if the establishment of districts was left to the Member States (Option 2), this would not be guaranteed and districts could be defined on the basis of administrative units (easiest option to implement and lowest cost). Stakeholders considered this would be highly counter-productive, as administrative units are not homogenous in relation to climatic condition, soil type and land use (whereas Options 3 and 4 will likely provide more homogeneity due to the input from the EC).

That said, some stakeholders also highlighted that some flexibility in the approach would be advantageous given that what determines soil health is dependent on location, soil type, and other parameters, in particular following a learning-by-doing or adaptive management approach as was the case under the Water Framework Directive. Stakeholders noted that indicators and descriptors should be standardised across the EU, however, only for those that are relevant to all Member States. Others noted that Member States should set thresholds in accordance to their specific situations. Such flexibility would be restricted under Option 4, relative to Option 3.

1.4 Findings

In summary, all options would deliver a significant improvement to the information, data and governance around soil health, and form a critical basis for other building blocks under the SHL. ***Option 3 appears to be the preferred option*** as it best balances the opposing risks of the potential for lack of consistency and comparability across Member States, and the complexity of one entity defining a set of thresholds that are applicable EU-wide. This option is considered the best to drive as far as possible consistent action and ambition EU-wide, whilst also respecting Member State independence and the requirements of soil to function healthily in their locality. Likewise allowing Member States some flexibility in defining districts but following a set of mandatory criteria on homogeneity defined by the EU should ensure that districts remain set in a way which ensures effective definition and monitoring of soil health, whilst also allowing the reflection of local, socio-geo-political factors to be considered in their definition.

Table 1-3: Overview of impacts

		Option 2	Option 3	Option 4
Effectiveness	Impact on soil health	(+)	(+)	(+)
	Information, data and common governance on soil health and management	++	+++	++
	Transition to sustainable soil management and restoration	(+)	(+)	(+)
Efficiency	Benefits	++	+++	++
	Adjustment costs	0	0	0
	Administrative burden	-	-	-
	Distribution of costs and benefits	-	-	0
Coherence		+/-	+	+
Risks for implementation		--	-	---

2 Analysis of Options under Monitoring (MON)

2.1 Description of the options

The objective of this building block is to make monitoring of soil health (through in-situ and remote monitoring) and of the progress in achieving soil health objectives a mandatory obligation across the EU, using LUCAS and remote sensing as an oversight system.

A number of Member States have existing soil monitoring schemes in place however they are fragmented, incomplete and in general not harmonised.[982] Member States deploy a variety of sampling methods, frequencies and densities, and use different metrics and analytical methods, thus showing a current lack of consistency and comparability across the EU. Furthermore, soil data is not consistently stored in one accessible database and taking samples can encounter the issue of access to land.

At an EU level, LUCAS Soil (part of the EUROSTAT programme LUCAS) provides harmonised soil measurements in the EU. However, LUCAS Soil alone is not sufficient, with its current low density of soil samples, to adequately assess soil at local level, given

[982] Reference - Soil strategy

the large variability of soil types, climatic conditions and land uses, and to use its measurements to adequately take local soil restoration actions. That said, LUCAS Soil offers substantial value as an existing, harmonised assessment of soil health at EU level that could present a reference for comparability of national measurements, but would require a clear legal basis which is not yet existing. Furthermore, remote sensing technologies such as Copernicus and related digital solutions already provide key data and information (such as land use and land cover, soil moisture) to complement ground measurements and reinforce the oversight system at EU level. In addition the requirement that environmental data should already be publicly available under the INSPIRE Directive is not yet sufficient to ensure coherent monitoring across the EU.

All options under this building block contain that: (a) Member States have an obligation to monitor in-situ and report on current status of soil health, for all 'soil districts' and for all soil descriptors of the 'minimum list', and report on progress towards targets at least every 5 years; and (b) the EU will establish a legal basis for LUCAS as the EU oversight system (to address the issue of the access to land, use of data and privacy for the LUCAS soil survey) and will monitor soil-related data from remote sensing. A monitoring network will need to be established across the EU which could be used to measure soil health across all descriptors in all districts to a reasonable level of robustness – the JRC has undertaken work to explore what such a network would look like, and has estimated that a sampling network with around 216,000 sites would be required to assess all criteria on the minimum list in all districts to an error of 5%.

Options 2, 3 and 4 then differ as follows:

- ***Option 2:*** List of international standard methods used by LUCAS Soil (see annex 9 for detail) remain indicative for Member States who have flexibility to define the method for measuring the soil parameters. Member States should use transfer functions from science where available to convert national measurements to achieve some level of harmonisation.
- ***Option 3:*** Member States can choose either to apply list of international standard methods used by LUCAS Soil or maintain their own methods. Member States should use scientifically validated transfer functions where methods in EU list are not applied.
- ***Option 4:*** List of international standard methods used by LUCAS Soil are made mandatory for all Member States. This would include use of transfer functions to convert national historic soil data EU-wide.

The development of transfer functions will build on existing work under the Horizon 2020 Joint Research Programme EJP Soil, where 24 Member States are participating, which is proceeding to validate some transfer functions for the measurements of soil parameters by taking double samples and measuring each with national or LUCAS soil methods.

2.2 Discussion of the relative impacts, costs and benefits of the options

All options under this building block put in place an EU-wide obligation for Member States to monitor in-situ and report on current status of soil health every 5 years, for all 'soil districts' and for all soil descriptors of the 'minimum list' (defined in SHSD). The achievement of healthy soils cannot happen if there is no obligation for Member States to regularly and adequately assess the soil health and monitor its status with time, together with the monitoring of the effectiveness of the measures taken. As such, all options will deliver significant improvements in the Information, data and governance of soil health and management. In addition, as with SHSD options, monitoring of soil health descriptors is a critical and necessary facilitating step to the subsequent implementation of effective soil health management and restoration actions. Regular measurements of soil health descriptors are required to be able to identify which soils are 'healthy' or 'unhealthy', and to identify, plan and implement a set of restoration measures expected to achieve good soil health. However, again as under SHSD, it is anticipated that there will be some variance between the options on the basis of risk and costs.

Furthermore, improvement in monitoring is expected to lead to direct economic impacts through technological development and innovation, and stimulate academic and industrial research, and there could also be a direct and positive impact on the conduct of business and position of SMEs such as laboratories within each Member State due to the increase in their services to carry out the analysis of the soil samples. Increasing the amount of publicly available soil monitoring data will help to increase the public awareness of soils and the challenges they face.

The key difference between the options is the degree of flexibility and harmonisation, and the entity responsible for defining the strategies for sampling and analysis. Where full flexibility in these matters is left to Member States (Option 2), there is a greater risk of variation in methods, strategies and precision between Member States. Although some improvements relative to the baseline will be achieved through the greater application of existing transfer functions, variability in the collection, analysis and reporting of soil samples (e.g. due to differences in laboratory techniques) is anticipated to be greatest under Option 2 relative to Options 3 and 4. This greater variability in monitoring will lead to lower comparability between Member States in terms of reporting and interpretation of monitoring data. A second factor is the ability to integrate and combine Member State monitoring data with LUCAS to achieve the overall number of sites required for a reliable assessment of soil health: Option 2 will only achieve partial integration based on available transfer functions and hence would not be able to combine monitoring data from national networks and LUCAS, whereas Option 3 will achieve full integration and under Option 4 methods would be harmonised and hence monitoring data from national networks and LUCAS could be combined. These risks carry disadvantages, in particular for Member States, who will subsequently need to invest greater financial and human resource, and face longer delays, in developing knowledge and resolving issues that stem from a lack of harmonisation when comparing across Member States, and will need to invest greater administrative resources in additional sampling sites to achieve the required number for reliable assessment (this is considered further in the quantification of administrative burden below). Under Option 2, there is also a risk that Member States who already have a monitoring framework in place simply continue with (or do not sufficiently expand) these systems (in some cases perpetuating outdated systems) (Indicator 'Risks for implementation': Option 2 '--').

On the contrary, a key risk around Option 4 is the complexity and burden required for all Member State to transition wholly to the international standards deployed by LUCAS. Should Option 4 be attempted, it may protract and significantly delay the implementation timetable due to the complexity of the task (Indicator 'Risks for Implementation': Option 4 '--'). Indeed, stakeholders noted through engagement that there will be some reluctance on behalf of some Member States to change and adopt harmonised approaches and others noted there is a need to consider existing practices in the Member States and rather add on to those to secure the continuity of soil monitoring. Hence, it may be beneficial to give Member States some flexibility around their preferred methods, and to judge their own cost-effectiveness of adopting the international standards used by LUCAS or instead to develop and use transfer functions to aid comparability. A further risk associated with Option 4 is that of laboratory capacity and location: Currently laboratory capacity with the expertise to process soil health samples is unevenly spread across Member States hence under Options 2 and 3 Member States have greater flexibility to design monitoring systems to better mitigate this risk in the short-term (Indicator 'Risks for Implementation': Option 3 '-'). That said: not all analysis requires laboratory support and some can be done in situ (e.g. compaction); sample transportation costs are small compared to that of performing some measurements; and capacity is anticipated to grow in response to an increase in demand.

As a consequence of these risks, the options are likely to have a different impact on the improvement of information and data around soil health. These risks are likely to limit the benefits of Options 2 and 4, relative to Option 3 (Indicators 'Information, data and common governance on soil health and management' and 'Benefits': Options 2 and 4 '++', Option 3 '+++'). Option 3 on one side shows a lower risk of inconsistency in monitoring standardisation in comparison to Option 2 whilst also reducing the risk surrounding some Member States not having the necessary expertise to develop a monitoring framework. On the other side, Option 3 proposes a more pragmatic solution relative to Option 4 – Option 3 would impose a smaller transition risk and allow those Member States who wish to maintain their existing methods to do so whilst ensuring data can be combined with LUCAS outputs and compared across Member States.

The key impact of this option will be the additional administrative burden placed on actors. The most significant cost is that of undertaking additional sampling, analysis and reporting/data collation, either at existing sampling sites (e.g. where the range of descriptors needs to be expanded or sampling frequency increased), or for new sampling sites (additional to the existing monitoring network of around 41,000 LUCAS and 34,000 Member State monitoring sites, which are captured in the baseline). The obligation to monitor will be placed on Member States, hence this is where the additional burden will fall in the first instance.

As shown in the table below, illustrative estimates of the administrative burden suggest that Option 2 may pose the greatest additional burden relative to the other options – this is driven primarily by the additional sampling costs. Under Option 2, Member States use existing transfer functions where available in science, and are not obligated to develop new functions where these do not currently exist. As such, data collected from new or existing sampling sites cannot be readily compared and combined with data collected under the LUCAS Programme. Hence to achieve a sampling network able to measure soil health to a sufficient robustness (i.e. a network of 216,000), given Member States can no longer use data from LUCAS sites, it is assumed that they must implement a greater number of new, additional sites to make up the shortfall. As such, it is anticipated that Option 2 would lead to a higher level of new sampling sites (around 195,000 additional sites)[983] and hence greater burden, relative to Options 3 and 4 (around 164,000 additional sites). Furthermore, less harmonisation under Option 2 will require Member States to invest greater financial and human resource, and face longer delays, in developing knowledge and resolving issues that stem from a lack of harmonisation when comparing across Member States.

[983] Note existing national sampling sites are included on a basis equivalent to 5-yearly sampling, hence given some Member States monitor less frequently, a lower equivalised number is represented in the baseline.

There will also be fairly large, upfront administrative burdens associated with developing and validating transfer functions between two systems (falling on Member States under Option 3 and the EC under Option 4). However, if a Members State has validated transfer functions towards LUCAS Soil for all parameters, it can integrate LUCAS Soil data to complete the minimum set of sample points needed. This may not be possible in Option 2 which has consequently higher recurrent monitoring costs.

There will also be significant costs under Option 4 associated with aligning processes and providing training where processes are harmonised across the EU (and these are different to existing processes in a given Member State). Option 4 aims to harmonise all elements of monitoring, e.g. whether one campaign is done every 5 years or a yearly rolling sampling, procedure when a sampling point is not accessible, how to take a sample, depth of sample etc., while Option 3 only aims to drive standardisation in the methodology to measure (or comparability in – where transfer functions are instead adopted -) the values of the soil descriptors. Indeed Option 4 is anticipated to lead to higher cost relative to Option 3 as where there is greater harmonisation in sampling and analysis methods EU-wide, this would require a greater change in processes and training to align with these requirements (note the difference in upfront costs appears smaller as these have been annualised over a 20-year period). Relative to the burden of other building blocks, the administrative burden of all options is deemed 'large' (Indicator 'Administrative burden': Options 2/3/4 '---').

Monitoring will also collect data on an ongoing basis related to the measures taken to improve soil to good health. Hence monitoring activities include the processing and assessment of this data, determining trends, assessing the effectiveness of actions taken and identify where additional action is required. This is captured in the ongoing administrative burdens assessed here.

Table 2-1: MON Option administrative burdens (EC = European Commission, MS = Member States; no administrative burden for any other actors – e.g. businesses nor citizens – has been identified) – further information on the method to calculating administrative burdens can be found in annex 0 section 6

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 2	54,000	28,000	180,000	49,000,000	240,000	49,000,000
Option 3	54,000	89,000	480,000	42,000,000	530,000	42,000,000
Option 4	70,000	150,000	640,000	42,000,000	710,000	42,000,000

The distribution in costs across Member States is somewhat uncertain. Many Member States already have some form of monitoring in place covering a varying range of descriptors, and there will be a varying number of districts across Member States. Under Option 2, given many Member States already have monitoring systems, any administrative burden for many Member States may be small (assuming existing monitoring systems continue to perpetuate). Under Option 4, where an EU-wide monitoring approach is defined, the costs for different Member States will depend on their varying starting positions and the number of districts they have – greater costs are likely for those with more districts, but those are also likely to be the larger, more populous Member States and hence it is not certain that there would be a significant imbalance of costs across Member States (Indicator 'Distribution of costs and benefits: Options 2/3/4 '0'). Otherwise, there is no significant driver of a differential impact between different stakeholders and stakeholder types – e.g. between rural and urban areas.

All options under this building block will not have any direct effects on soil health and the environment (Indicators 'Impacts on soil health' and 'transition to sustainable soil management': Options 2/3/4 (+)). Likewise these options will not carry with them an adjustment cost (Indicator: Options 2/3/4 '0'). That said, as noted above, the systematic collection of data against the soil health descriptors is a critical prerequisite of the effectiveness of those building blocks under which action will be taken to restore soil to good health - identifying, planning and taking action requires first a clear understanding of the problem identified by the sample. Action under these building blocks will incur an adjustment cost but also deliver the economic, environmental and social benefits associated with improved soil health (i.e. SSM, REST/REM). As such, the option selected under MON is one of a number of variables that will have a strong influence on the adjustment costs under these building blocks and hence the frequency and quality of soil monitoring will have a significant indirect impact on the soil and surrounding environment.

Options 3 and 4 (as under SHSD) are considered marginally more consistent with all options under the other building blocks – for example, Option 2 where Member States define sampling strategies is likely to be inconsistent with Option 4 under SSM or REST, where a set of measures to maintain or restore soil health is defined at EU-level. The same is somewhat true where Option 4 under MON is combined with Option 2 under SSM and REST, however even where soil health descriptors are defined at EU-level, it is perhaps not as inconsistent that a programme of measures could be defined by Member States (Indicator 'coherence': Option 2 '+/-', Options 3 and 4 '+').

2.3 Summary of stakeholder views

Overall, respondents indicated that there is a clear need for improvement in the standardisation of monitoring. In response to the OPC, there was a strong agreement across all stakeholder types that there should be legal obligations for Member States to monitor soil health in their national territory and report on it. 89% of all respondents 'totally agreed' this obligation should be put in place, with a further 8% 'somewhat agreeing'. 'Totally agree' was also the most common response across all stakeholder types, with Business Associations being the only exception, where 'somewhat agree' was the most frequent response (but followed by 'totally agree'). Stakeholders emphasised the key issue presently is the lack of harmonisation of approaches to collect and compare data.

Alongside monitoring, stakeholders also highlighted the importance in (and benefit of obligating) reporting across Member States, in particular achieving standardisation across Member States

Although there was strong consensus around the need for further harmonisation, there was no consensus on the specificities of standardisation- including where in the process chain of monitoring standardisation could be applied. Some noted that ISO standards for laboratory processes exist and can be adopted now. Furthermore, several stakeholders noted it would be a significant challenge to try and achieve harmonisation EU-wide in all aspects of the monitoring process – e.g. stakeholders highlighted that there are multiple ways to analyse the same soil health descriptor, especially considering the diversity of climate, soil types and land-uses across the EU.

Stakeholders also noted there will be some reluctance on behalf of some Member States to change and adopt harmonised approaches. Some noted there is a need to consider existing practices in the Member States and rather add on to those to secure the continuity of soil monitoring. A minority of stakeholders also highlighted a preference for national systems that are risk-based (hence taking samples where needed instead of being evenly distributed across districts) and consider cost-benefit aspects, thus not simply testing for a pre-defined set of actions, to maximise feasibility of the monitoring programme.

2.4 Findings

In summary, all options would deliver a significant improvement to the information, data and governance around soil health, and form a critical basis for other building blocks under the SHL. ***Option 3 appears to be the preferred option*** as it best balances the opposing risks of the potential for lack of consistency and comparability across Member States, and the complexity of one entity defining a set of monitoring processes that are applicable EU-wide. The feedback from stakeholders suggests there is a demand for standardisation where possible, and that there are several descriptors for which this is more achievable (e.g. nutrient status, soil organic carbon). Furthermore, greater harmonisation and guidance around the development of sampling strategies could be beneficial and feasible – for example, general guidance on how many samples to take, where, how these should be taken and analysed – without being overly prescriptive. That said, it would be beneficial for some flexibility to be retained at Member State level to be able to effectively apply monitoring and sampling strategies to the specifics of a given district (e.g. variance in land parcels, and/or defining an appropriate strategy for descriptors that are more technically complex to define, such as biodiversity).

Table 2-2: Overview of impacts

		Option 2	Option 3	Option 4
Effectiveness	**Impact on soil health**	(+)	(+)	(+)
	Information, data and common governance on soil health and management	++	+++	++
	Transition to sustainable soil management and restoration	(+)	(+)	(+)
Efficiency	**Benefits**	++	+++	++
	Adjustment costs	0	0	0
	Administrative burden	---	---	---
	Distribution of costs and benefits	0	0	0
Coherence		+/-	+	+
Risks for implementation		--	-	--

3 ANALYSIS OF OPTIONS UNDER SUSTAINABLE SOIL MANAGEMENT PRACTICES

3.1 Description of the options

The way land is used can have a major impact on soils, and on soil health. In the EU, agriculture and forestry are the two major land uses relying on soil, however, urban areas also contain a significant share of unsealed soils, and all soils need to be managed in a healthy, sustainable way to ensure the provision of long-term ecosystem services. Current data and research show that a large proportion of soils are already degraded, and that soil degradation is continuing due to a variety of factors that are often not addressed and are perpetuated by continued unsuitable management practices. Some existing policies target the uptake of SSM practices to a certain extent. In particular the CAP is the most targeted policy mechanism in terms of supporting soil health through conditionality, and AECCs. However, at EU level, there is no dedicated soil policy which ensures the sustainable use of all managed soils nor with binding requirements for landowners and managers to implement a comprehensive set of sustainable soil management practices. In its place, there is a set of agricultural policies, water protection policies, nutrient management policies, and air quality, flood risk management and climate policies that influence the way soils are managed (although soil protection is not the explicit objective of these policies).

The European Commission seeks to make the sustainable use of soil the new normal. This building block enables the necessary transition to sustainable management of soils across the EU by providing a definition of sustainable soil management (SSM) and establishing the principles of sustainable soil management. This building block directly targets the key problem that soils in the EU are unhealthy and continue to partially degrade due to widespread unsustainable or harmful practices. Consequently, action must be taken to improve soil management.

All options under this building block capture that the EU will provide a definition of SSM; ; and establish the principles of sustainable soil management closely following existing guidelines and scientific recommendations - these principles will target all relevant soil threats for agricultural, forest and urban soils. It also requires, in a second stage only, Member States to apply, in a proportionate manner, the principle of non-deterioration of soil health. The options then differ in the following respect:

- ***Option 2:*** The principles of sustainable soil management will be included in an indicative annex and can be used by Member States as guidance in developing their own criteria and classification of sustainable management practices for all soils while still giving them the necessary flexibility on how to implement those principles. Hence the definition of SSM practices is left to Member States who can choose which practices they think should be regulated within their territory.
- ***Option 3:*** The principles of SSM defined by the EU will be mandatory and Member States are obliged to enforce these for land managers and other relevant stakeholders (could include principles similar to the CAP GAEC standards that support soil health). Member States would still retain some flexibility concerning the implementation of specific management practices and can choose to apply additional requirements going beyond the minimum list of mandatory principles.
- ***Option 4:*** the principles are translated into a broad, even if not exhaustive, list of concrete, binding SSM practices and of banned harmful practices applicable to all types of soils in the EU.

3.2 Discussion of the relative impacts, costs and benefits of the options

The number of SSM practices that can be applied to improve soil health is extensive (see section 9). SSM practices can have different types and sizes of effects across varying ranges of soil health pressures (such as erosion, compaction, and salinisation, etc) and their impacts, costs and benefits are highly dependent on location, land-use, soil type, and climate. SSM practices exist for agricultural, forest and urban soils (and in some cases some practices are applicable across two or all three area types). Examples include: crop rotation and reduced stocking density (agriculture), continuous forest cover and avoidance of clear felling (forestry), reforestation (forest and urban), installation of surface and subsurface drainage (agriculture and urban), and use of soil management or nutrient plans, integrated pest management, protection of habitats, biodiversity and wetlands, use of natural drainage and water re-use (agriculture, forestry and urban soils).

The impacts of the options under this building block will be driven by the principles and guidelines indicated in the SHL, which of those principles become mandatory under different options, and ultimately which SSM practices are selected by Member States for implementation. These actions will in part be influenced by the definition of soil health and districts (and hence the option selected under SHSD) and the soil monitoring programme (and hence the option selected under MON), as these choices will directly identify those districts and areas where soil is most degraded, and subsequently what action needs to be taken to achieve good soil health.

Providing a definition of sustainable soil management under EU law and making it mandatory for Member States to ensure that this definition is fully applied will significantly contribute to the transition to sustainable soil management under all options.

The subsequent implementation of SSM practices to put the principles into practice to maintain and improve soils that are currently not sustainably managed has very positive impacts on the environment and the quality of natural resources. Implementation of SSM can deliver: improvements in food production and food security (agriculture), sequestration of carbon and reducing climate change risks (all soils), improve quality of natural resources (soil, but also air and water – including water infiltration and retention, reducing the risks of nutrient and pesticide leaching into watercourses), and improved public health and safety (e.g. through reduced flood risk - all soils). Furthermore, high soil biodiversity positively affects aboveground biodiversity, helps regulate greenhouse gases, supports the retention of nutrients in the soil and can improve biotic resistance to pests. Sustainably managed soils provide a wide range of stable ecosystem services that are important not only in natural landscapes but also in urban areas. Although methods are not available to comprehensively quantify and monetise these impacts EU-wide, there is strong evidence from a wide range of studies looking at specific measures deployed at individual land-parcel level (see for example extensive work undertaken by RECARE[984], multiple studies funded under the LIFE Programme, and Rejesus et al. (2021),[985] Brady et al. (2019),[986] amongst others) and broad consensus amongst stakeholders (both in response to engagement, but also separately – see for example extensive work by EJP soils),[987] that SSM practices on agricultural, forest and urban soils can deliver environmental benefits both in the short and long-term through continued and enhanced provision of ecosystem services. Furthermore, estimates of the costs of inaction (which SSM practices would work towards avoiding and hence accrue as a benefit) are substantial: the order of magnitude of the costs of soil degradation had been estimation atEUR 50 billion annually[988] for all 27 Member States.

All SSM practices will carry an adjustment cost, which is likely to be one of the most significant impacts associated with the options under this building block (Indicator 'Adjustment cost': Options 2/3/4 '---'). The magnitude of these costs and benefits

[984] RECARE 2018
[985] Economic dimensions of soil health practices that sequester carbon: Promising research directions (jswconline.org)
[986] Sustainability | Free Full-Text | Roadmap for Valuing Soil Ecosystem Services to Inform Multi-Level Decision-Making in Agriculture (mdpi.com)
[987] See for example, survey of project partners under i-SoMPE: https://ejpsoil.eu/about-ejp-soil/news-events/item/artikel/innovative-soil-management-practices-across-europe
[988] Report of the Mission board for Soil health and food (2020),

depends largely on the required change in current management practices but also on the ambition of the SSM practices in question. More ambitious practices are associated with higher investment costs for individual soil managers, such as for machinery renewal, or agroforestry investments. Higher ongoing costs may arise for practices of all ambition levels that require higher or more expensive inputs compared to current practices. Additional costs could also arise from the transition to more labour-intensive practices, resulting in increased overall salary costs, for example.

That said, the implementation of SSM practices can also have a positive economic impact through reduced costs or financial benefits for individual soil managers (for example through yield improvements, raw material savings, or water retention and flood remediation). In some cases, SSM practices in particular on agricultural soils can deliver an economic payback to landowners or managers, even before the environmental benefits of such practices are considered. If SSM practices can be tailored to land parcels and effectively implemented, there is a greater opportunity for longer term positive economic effects. In agriculture and forestry, the implementation of SSM has the potential to lead to more diverse production systems, which in turn may prove more resilient to external fluctuations in climate, market prices, and supply-demand, by having a wider range of marketable products. It is important to note however that even where SSM practices deliver a net return, it may take several years before benefits start to be achieved and many years before the payback is realised (e.g. sometimes up to 10 years or more). The trade-off of economic costs and benefits will vary significantly by practice-type and may vary significantly for each individual practice depending on the conditions and location in which is implemented. The following table presents some illustrative, quantitative analysis based on case studies where practices have delivered a positive economic return, and a simple extrapolation of these impacts to EU-level to illustrate the potential magnitude of effects.

Table 3-1: Illustrative estimates of the total costs and benefits of specific agricultural SSM practices deployed EU-wide (costs denoted with '-' are costs, i.e. not benefits) (2020 prices)

SSM practice	Economic costs	Economic benefits
Cover crops (applied to arable land growing cereals with bare soil over winter)	-2.8 bn EUR pa	9.3 to 9.5 bn EUR pa
Reduced tillage (applied to arable land using conventional tillage)	-13 bn EUR pa	6 to 12bn EUR pa
Crop rotation (applied to barley production)	-0.12 bn EUR pa	0.6 bn EUR pa
Use of organic manures	-1.5 bn to – 10.5 bn EUR pa	1.39 bn to 2.7 bn EUR pa
Reduction in stocking density	- 8.1bn EUR pa	0.6 to 2.7bn pa

Several of the environmental benefits can be associated with positive social impacts in the short- to long-term. Increased carbon sequestration potential, for example, helps reduce the risks and associated costs caused by climatic change. Improved flood mitigation not only reduces the societal costs associated with flooding but also substantially improves the safety and quality of life of people living in flood risk areas. Diversified farming and forestry systems provide opportunities for new jobs and an improved value of landscape can accelerate the growth of business and livelihoods, e. g. for tourism, markets, and infrastructure. However, depending on the type of SSM practice, loss of employment may also be possible to a certain extend where management practices require less labour.

Comparing between the options in terms of benefits and costs is uncertain, as it is challenging to judge whether the level of activity (and associated costs) would be greater where full flexibility is left to Member States (Option 2) or where concrete, binding management practices for all types of soils in the EU are implemented EU-wide (Option 4), or a central option (3).

Under Option 2, leaving full flexibility to Member States increases the risk that there will be inconsistency in the implementation and ambition across Member States (Indicator 'Risks for implementation': Option 2 '---'). Should some Member States implement a minimum or limited number of recommendations and restrictions, this may not be sufficient to prevent continuing degradation of agricultural, forest and urban soil health. Leaving Member States to decide on which practices they can mandate or encourage the uptake of leaves room for harmful practices to continue without reparation. This may be particularly the case for urban or forest soils, where there is currently less focus under existing legislation on limiting soil degradation. Hence under Option 2 there is a risk of a 'race to the bottom' in terms of ambition across Member States, and a resulting uneven playing field for actors in affected industries and between industries across the EU.

Under Option 4, a key risk is the challenge associated with defining a list of mandated and prohibited practices that are applicable EU-wide, covering differences between all Member States, localities, climates, soil types, agricultural systems, and cultural norms. While there may be options that can be mandated with reasonable confidence that they are universal (e.g. education and training, etc), defining a list of in-field measures to implement will be difficult. This risk could manifest in several forms. Where an intensive effort is made to define a detailed list which is widely applicable in different scenarios, this could protract the delivery timeframe, increase the administrative burden for the EC and the complexity of implementation for Member States and landowners and managers. Should a simpler approach be taken, the list of practices mandated across the EU could be very short to ensure the list is applicable across the board, limiting the additional ambition and impact of Option 4 (and to a certain extent Option 3) over Option 2. If a longer list is decided on that is not tailored to each Member State, this could lead to action which is ineffective, inefficient and even detrimental, and a lack of meaningful implementation. There is a high risk of push back from land managers, as well as farming and land-use trade bodies, membership associations and industry stakeholders alongside Member States on this option, particularly if there is a lack of applicability in the list of mandated measures (Indicator 'Risks of implementation': Option 4 '---'). Given Option 3 utilises a set of principles that are already somewhat mandated EU-wide and likely to mandate a shorter list of practices, the risk is lower than for Option 4 (Indicator 'Risks of implementation': Option 3 '--').

For Option 3, the additional impact relative to Option 2 focuses on the application of the mandatory management principles. Assuming some principles will be similar to those already implemented under the CAP GAEC standards, which are estimated to cover up to 90% of the agriculturally productive land in the EU, the inclusion of this option would mean that these will then apply also to the remaining 10% of agricultural land, as well as to other land types, such as forestry and urban areas where SSM practices can be applicable (noting that current GAEC standards have little relevance to non-agricultural land-uses, and would need to be adaptable to forest and urban landscapes).

Between the options, the risk of inconsistency between Member States under Option 2 and of a protracted process to define a universally applicable list under Option 4 could impact on the achievement of these options with respect to improvements of soil health relative to Option 3 (Indicators 'impact on soil health' and 'Transition to sustainable soil management and restoration’: Options 2 and 4 ‘++’, Option 3 ‘+++’). Option 2 may create reduced adjustment costs as compared to the other options given the greater flexibility for Member States, while the mandatory implementation and banning of specific principles / practices under Options 3, and respectively 4, will require more stringent enforcement, and monitoring, by Member States. However, these costs will highly depend on the specific practices to be implemented and the starting point in each Member State.

All options under this building block are anticipated to deliver a significant improvement in the governance of soil health by: placing the obligation on Member States to ensure soils are sustainably managed.

For Options 2 and 3, additional administrative burdens (relative to options under other building blocks) are anticipated to be small (Indicator ‘administrative burden’: Options 2/3 ‘-‘) – estimates are presented in the table below. The main burden is anticipated to be associated with the obligation to implement/ban very precise practices, which is mandated under Option 4 (Indicator ‘administrative burden’: Option 4 ‘--‘). The administrative burden for the EC is also higher under Option 4 as it is assumed that the list of SSM practices to be established would need to be much more detailed.

Table 3-2: SSM Option administrative burdens (EC = European Commission, MS = Member States; no administrative burden for any other actors – e.g. businesses nor citizens – has been identified) – further information on the method to calculating administrative burden for any other actors – e.g. businesses nor citizens – has been identified) – further information on the method to calculating administrative burdens can be found in annex 9 section 6

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Option 2	25,000	24,000	9,100	-	34,000	24,000
Option 3	29,000	24,000	45,000	-	74,000	24,000
Option 4	76,000	48,000	4,800,000	-	4,900,000	48,000

Under the SSM options, the obligation to manage soil sustainably sits with Member States. That being said, urban and rural land managers (URLMs) will have an important role in implementing the required SSM practices. The distribution of costs and benefits is highly dependent on the type of implementation (voluntary or obligatory), the extent of practices, and the area over which new practices must be established. At this stage it is uncertain where costs will fall. Furthermore, although some SSM practices may deliver a positive economic return, not all practices do, and many of the benefits may take years to emerge, and/or take many years to 'payback'. Tenant farmers and land managers in particular are likely to capture a lower proportion of any economic returns from improved soil function (e.g. yield or resilience to extreme weather) which takes many years to realise, in comparison to the land owners and non-tenant farmers. This is due to a range of barriers, such as short-term farm tenures rendering the tenant unable to capture all the benefit given the time limit of their tenancy agreement. Hence, although uncertain, there is potential for the distribution of costs and benefits to be unequal under all options between Member States and different stakeholders involved (Indicator 'Distribution of costs and benefits': Options 2/3/4 '--'). Furthermore, measures are likely to predominantly impact rural areas as agricultural and forestry land represents a greater land area, soils are more actively managed and nutrients are applied in greater amounts – hence the costs (and benefits) of implementing these measures will also fall more so on rural areas.

With respect to coherence, all options are broadly coherent with options under other building blocks. That said, Option 4 could be seen to be slightly less coherent with options under other building blocks where greater flexibility is left to Member States, such as Option 2 under SHSD (Indicator 'coherence': Option 2 '+', Options 3 and 4 '+/-'). Furthermore, Options 3 and 4 carry with them a greater risk of overlap with other legislation, in particular with agriculture and the CAP – where certain practices are mandated or prohibited, both the SHL and CAP would apply separately to the same areas of land.

3.3 Summary of stakeholder views

In response to the OPC, there was a strong agreement across all stakeholder types that there should be a legal obligation for Member States to set requirements for the sustainable use of soil so that its capacity to produce food, filtrate water, host and support biodiversity, store carbon etc. is not hampered. 89% of all respondents 'totally agreed' this obligation should be put in place, with a further 8% 'somewhat agreeing'. 'Totally agree' was also the most common (or joint most common in the case of Trade Unions) response across all stakeholder types.

A general risk is whether URLMs have sufficient expertise to implement the SSM. Stakeholders noted that there is a need to anchor the shared experience of URLMs to build a toolbox and provide education. An additional risk, highlighted by stakeholders is the financial aspect. Given many practices involve an upfront cost, and economic benefits (if any or if sufficient to outweigh the costs) accruing overtime, upfront investment could place a barrier to take up of measures.

Between the options, stakeholders highlighted that a key risk of leaving full flexibility to Member States (Option 2) is that it would be possible that Member States and land managers may go for the minimum (e.g. race to the bottom). Some stakeholders noted that if the EC and Member States can agree that certain practices are dangerous for soil (such as burning and peat extraction), then they should be banned explicitly in the law. There was a general consensus amongst stakeholders for the need to establish guidance to Member States on defining sustainable soil management.

That said, stakeholders also highlighted that there is a need for some flexibility to adapt to national circumstances/soil management. A number of stakeholders highlighted that every soil region and district is different, hence appropriate soil management would need to differ according to topography, and other location specific parameters. Stakeholders noted the example of the impact of spreading organic manures/fertilisers on compaction, and the risk that the amendments and machinery required could in some circumstances harm the soil structurally.

Furthermore, stakeholders also highlighted that where any practices are mandated or prohibited, the underlying rationale would need to be clear and robust given the sensitivities of that mandatory practices amongst the farming community in particular.

Stakeholders also highlighted that where practices are prohibited or mandated (Option 4), there is a risk around the interactions with other legislation (in particular the CAP where certain practices are also mandated or prohibited), with the potential to add complexity and burden on farmers.

With respect to Option 3 specifically, including forested and non-agricultural areas under this option was highlighted as positive by several stakeholders. Stakeholders also noted the GAECs offered a pragmatic list of measures that could be adopted relatively quickly.

Stakeholders also offered opinions on a range of SSM practices specifically. A key theme amongst responses was the benefit seen in building knowledge and networks across URLMs. This can be done in a range of ways, such as through: facilitating the exchange of shared experiences between URLMs; and improving education, e.g. including SSM as part of national curricula and programmes and workshops for farmers. In response to the OPC, a majority of respondents viewed 'Member States funding SSM training for farmers and farm advisory services', 'Creating networks, collecting and disseminating good practices and success stories' and 'Provide platforms for promoting SSM practices (e.g. lighthouses, living labs)' all as 'very effective' measures to ensure SSM.

3.4 Findings

In summary, all options under this building block are anticipated to deliver a significant improvement in the governance of soil health and in soil health itself across agriculture, forest and urban areas. The impacts will be driven by the principles and guidelines developed by the EC, which of those principles become mandatory under different options, and ultimately which SSM practices are selected by Member States for implementation. Under Option 4, developing a set of EU-wide applicable practices is challenging – this may manifest in a number of outcomes that would undermine the effectiveness of this Option, for example protracting the timeframe to develop an EU-wide applicable list, or resulting in a list of broader categories of SSM (e.g. 'cover crops') without sufficient detail as to be effective (e.g. type of cover crop, timing of sowing, etc). That said, where it is possible to define practices that should be mandated or prohibited EU-wide, there is appetite amongst stakeholders for this: in particular, there are a range of agricultural and non-agricultural practices that can be highly degrading towards soil health, such as poorly managed rotational burning, clear felling, and peat extraction, where there is great potential to improve soil health from banning such practices with broad support already noted across Member States. Furthermore, there may be a range of 'supporting' measures (e.g. training, inclusion of SSM in education curricula, soil management or management plans at land parcel or project level, etc), where their application depends less on local conditions. Hence ***the preferred option selected is Option 3*** is deemed feasible and likely to achieve additional benefits over Option 2, but avoids the significant risks associated with going further under Option 4. Option 3 respects the need for flexibility allowing more efficient choices to be made.

Table 3-3: Overview of impacts

		Option 2	Option 3	Option 4
Effectiveness	**Impact on soil health**	++	+++	++
	Information, data and common governance on soil health and management	++	++	+++
	Transition to sustainable soil management and restoration	++	+++	++
Efficiency	**Benefits**	++	+++	++
	Adjustment costs	---	---	---
	Administrative burden	-	-	--
	Distribution of costs and benefits	--	--	--
Coherence		+	+/-	+/-
Risks for implementation		---	--	---

(*) Option 4 is expected to have the highest adjustment costs while benefits are presumably higher primarily for society and only delayed for land users.

4 Analysis of Options under Definition and Identification of Contaminated Sites (DEF)

4.1 Description of the options

Contaminated land poses a significant risk to human and environmental health. Efforts across Member States to remediate contaminated sites (CS) vary widely - some are at an advanced stage after decades of identifying and remediating sites, meanwhile others have only started to address soil contamination more recently. The identification of (potentially) contaminated sites is a prerequisite for remediation. However, contaminated site definitions and inventories are not legally required across the EU. Instead, the EU has encouraged Member States to assess and identify contaminated sites on a voluntary basis. As a result, existing activities to identify CS have been insufficient to investigate and identify all sites in Europe because reporting has been voluntary, irregular, incomplete, and inconsistent across Member States, and Member States do not currently share common definitions for soil polluting activities. There is also no certitude to whether and when action will be taken to remediate sites that pose a risk to either human or environmental health.

The objective of this building block is to facilitate the implementation of remediation measures on contaminated sites under the REST/REM building block by requiring Member States to identify, investigate, and risk assess all (potentially) contaminated sites (CSs and PCSs) in the EU and to make this information publicly available in the form of contaminated site inventories. This information is critical to direct remediation efforts to contaminated sites across Europe to remove chemical contamination that would otherwise continue, or have potential to, harm human health and the environment.

Member States would be obligated to systematically register potentially contaminated or suspected sites, and subsequently, to confirm the presence or absence of contamination on these potentially contaminated sites. The approach needs to define the conditions that trigger registration, investigation and sampling of potentially contaminated sites (achieving a balance so that the number of correctly identified sites needing further investigation and/or remediation is maximised, while the number of superfluous investigations, e.g. false positive results, is minimised). Member States would be obligated to assess the need for further action for contaminated sites. and should establish a public register of PCS, CS and CS requiring further action. The options then differ as follows:

- ***Option 2:*** applies a risk-based approach to estimate the magnitude and probability of the adverse effects of contaminated sites for human health and the environment. Member States will establish and apply a national methodology or procedure for risk assessment and define the risk level for human health and the environment that they consider (un)acceptable
- ***Option 3:*** also introduces a risk-based approach and obliges Member States to define risk assessment procedures and methodologies, but does not leave them full flexibility. Member States will establish and apply a national methodology or procedure based on some common EU principles for risk assessment. These common principles could be defined either immediately in the legal proposal, or later through a comitology procedure in cooperation with Member States experts, and could include, e.g. common risk assessment methodologies, common criteria for risks to health and the environment which should be assessed. Member States will keep full freedom and responsibility to define the risk level for human health and the environment that is considered (un)acceptable
- ***Option 4:*** Instead of allowing Member States to implement risk-based approaches, Option 4 would require the EU to devise a harmonised limit values (generic soil screening values) for a defined list of soil contaminants. Exceedance of these limit values would automatically trigger the need for further action on contaminated sites, without the need for site-specific risk considerations. This option would result in a single method to identify contaminated sites across the EU and leaves almost no flexibility to Member states to decide on the need to take further measures (e.g. remediation) on sites.

4.2 Discussion of the relative impacts, costs and benefits of the options

The DEF options, by defining, identifying and risk-profiling PCS and CS, are a prerequisite for remediation activities on CS under the REM building block and consequently the objectives of the REM building block could not be achieved without an option implemented under DEF. More broadly, this indicates the importance of this measure for the EU ambition towards a toxic-free environment. Options 2, 3 and 4 under this block introduce an obligation for Member States to register systematically potentially contaminated or suspected sites, and subsequently, to confirm the presence or absence of contamination on these potentially contaminated sites. The main benefit of the measures under DEF options is the facilitation of remediation to improve environmental and health protection, and to bring economic benefits through regenerating land value. In addition to facilitation of REM measures, the DEF measures would likely promote prevention of contamination and deter future polluters, enhancing these benefits over time. The options would facilitate movement towards a level-playing field between Member States as the measures would narrow the gap between Member States currently making limited progress in identification of PCS/CS and those who have already made significant progress to date.

Detailed and publicly available registers allow the tracking of progress, improve the governance, increase knowledge and information, and support well-informed decision making on the need for further action and to improve the health of these sites (under building block REST/REM). The need for additional monitoring is emphasised as a key message in the EEA's Zero Pollution Monitoring Assessment 2022[989], where they note that: *Less is known about soil pollution and its associated impacts on ecosystems than about other issues, such as air pollution. There is a need for ongoing, targeted monitoring to better inform decision-making and to assess progress towards meeting the long-term zero pollution objectives.* Hence all DEF options will deliver a significant improvement in information, data and governance of soil health (Indicator – Options 2/3/4 '+++').

How the risks of CS are assessed under DEF will determine to a great extent the ambition, benefits and costs of the REM building block 5. Therefore, the mechanism of introduction of DEF measures would determine the scale of indirect impacts, including a decreased presence of toxic chemicals in the environment, consequential positive impacts on species, populations, biodiversity, groundwater, the provision of ecosystem services, health, and economic benefits as well as costs.

The key difference between the options under this building block is flexibility around the choice of risk acceptability and the approach to estimate the magnitude and probability of the adverse effects of contaminated sites for human health and the environment. Under Options 2 and 3, Member States are obliged to establish national procedures and methodologies for the assessment of the risks of contaminated sites, but in Option 3, Member States have to do this by taking into account the common EU guiding principles for the risk assessment procedure. In both Options 2 and 3 Member States keep full freedom and responsibility to decide on the risk levels they find un/acceptable for human health and the environment. Option 4 no longer applies a risk-based approach for the management of contaminated sites as EU-wide limit values for contaminants are defined by the EU. Exceedance of these values would automatically require further action for

[989] https://www.eea.europa.eu/publications/zero-pollution/ecosystems/soil-pollution

contaminated sites, and hence leaves almost no flexibility to Member States to decide on the need to take further measures. The effect that these different structures will have on implementation in practice is challenging – it is somewhat uncertain at this stage whether any option will facilitate remediation to a greater or lesser extent. That said there are differences in risks that may then influence the outcomes of different options.

Option 2 (relative to Options 3 and 4) offers the greatest amount of flexibility to Member States to define acceptable risk levels. Option 2 could allow Member States to apply less effective investigation techniques, which may fail to identify all CSs requiring further action. This in turn may lead to a lower than effective level of remediation activity in some Member States, and not address the currently uneven playing field across the EU. Historic trends in remediation activity across Member States can be viewed as evidence for this risk, as all Member States currently have the option to remediate sites, but ambition and progress has varied significantly (Indicator 'risks for implementation': Option 2 '---').

Option 3 would likely reduce the risk that Member States could implement insufficient investigation techniques, as common principles set by the EU would aim to ensure investigations meet a minimum standard. This would maximise the number of CS needing remediation identified, while avoiding false positive results which could occur if no flexibility was granted, likely achieving greater proportionality and effectiveness in comparison to the other options. Guidance from the EU in the form of common principles would particularly benefit those Member States who have limited national approaches to identifying PCSs/CSs.

On the other hand, Option 4 mandates a non-risk-based approach with common EU limit values for contaminants. Exceedance of these values would automatically require further action for contaminated sites. The key advantages of screening values are the speed and ease of application, the clarity for polluters and regulators, the comparability, transparency and easiness of understanding by non-specialists. Furthermore, applying a common approach across the EU could contribute more to a level playing field between Member States. However, having one standard method across the EU presents a challenge as it does not allow flexibility to reflect the particularities of each Member State and of specific sites. For example: differences between soils in different Member States (which can influence the ability of the soil to buffer contaminants), the spread of the hazardous substances, and the proximity of sensitive human and environmental receptors (and hence the exposure of people and the environment to harm) will all influence the size of the risk posed to human and environmental health. Lack of consideration of these aspects could result in inefficient identification of sites requiring remediation, and therefore incur disproportionate remediation. Moreover, it would be difficult to reach an agreement among Member States on the unification of values, since existing registers and monitoring systems are based on national instruments (Indicator 'risks for implementation': Option 4 '--'). This Option would likely require highest efforts from Member States to adapt their current investigation methods, as most Member States currently apply site-specific risk assessment methods rather than screening values. This could more negatively affect Member States who have already made significant progress, therefore countering the progress towards a level playing field.

The main potential difference between the options is the number of sites expected to be identified, and hence number of investigations and remediation projects expected. Option 2 may be likely to identify the fewest sites (as Member States would not be held to any common principles) and therefore could incur lowest costs and benefits. Option 3 could identify more sites as Member States would be held to a certain standard in terms of investigation. This would result in higher costs and benefits. It is unclear whether Option 4 would lead to the identification of more or less sites, as direct comparison of risk-based methods and soil screening value methods is challenging. Given concerns that soil screening value methods lack sensitivity to important geographic factors, there is a high risk that Option 4 could lead to the inefficient identification or sites requiring remediation (identifying more sites) or incorrect dismissal of sites that need remediation (identifying less sites). While Option 4 cannot be compared in terms of number of identified sites expected, it could lead to disproportionate costs and less effectiveness.

As the benefits from DEF are largely indirect benefits from the facilitation of REM, these are compared in the section below for each option. It should be noted that the above-described potential differences in number of sites identified will influence the scale of economic, social, and health benefits, just as they influence costs (described below).

The key cost (and main economic impact) associated with the options under this building block will be the cost associated with the registration, preliminary investigation and more detailed investigation (e.g. including sampling of potentially contaminated sites)[990]. The costs of identifying CS can be significant, hence it is essential to strike the right balance between maximising the number of positive soil investigations that detect contamination and minimising the number of superfluous or negative soil investigations. Although significant, there is a wide range of uncertainty around estimating the costs of site investigation as the number of sites requiring investigation is unknown:

- the number of sites requiring preliminary survey is estimated to be 2.8 million;
- the number of sites requiring preliminary investigation is estimated to be 1.9 million; and
- the number of sites requiring main site investigation is estimated to be 1 million.

Furthermore, estimates of investigation costs vary widely: most from €500 to €50,000 per site, and even €5 million in some instances in the Netherlands.[991] Preliminary site investigations are less costly than main site investigations, e.g. in Flanders, the average cost for preliminary investigation is €4,500, and €15,000 for the main site investigation. If a preliminary investigation does not render an indication of contamination, there is no need to proceed with the more expensive in-depth investigation.

The total cost of investigating sites could be approximately €24 billion in total. If spread over 15 years, this could cost €1.6 billion per year (1.9 billion in 2023 prices), reflecting 185,000 preliminary surveys, 125,000 preliminary investigations, and 65,000 main site investigations. Costs are uncertain, and could be several times higher depending on the scope for polluting activities considered to trigger investigation. These costs could be up to 10 fold higher than costs under the baseline, but again, the comparison is highly uncertain. Critically, these costs affect only specific Member States, i.e. where limited progress has been made to date (Bulgaria, Slovakia, Malta, Slovenia, Portugal, Poland, Ireland, Romania, and Greece). On the other hand, the Netherlands has already completed investigation, and Austria, Denmark, and Sweden have made high progress, indicating feasibility of the DEF measures. Any increase in economic costs of investigation would depend on the time horizon set for Member States to identify all

[990] This has been classified as an administrative burden, rather than an adjustment cost
[991] JRC (2014) p. 23

PCSs and CSs. Administrative burden under all options will be significant (Indicator: Options 2/3/4 '---'). Member States that need to establish or significantly improve their registers additional to the baseline scenario will incur an administrative burden, e.g. staff costs, development of IT infrastructure or a website – but these costs will be substantially less than the cost of investigation. Businesses might experience additional administration and communication due to the identification, registration and identification of contaminated sites. The administrative cost is estimated roughly to be 1% of the investigation cost.

It is uncertain exactly on whom these costs will fall in practice. Across the EU, both public authorities and the private sector bear costs associated with the remediation of contaminated soils.[992] Distribution of expenditure varies substantially between Member States, but on average, more than 43% of costs are borne by public authorities[993] (mostly national authorities, but also the EU where funding has been provided to some Member States). The remainder is left for the private sector, including polluters and landowners. Assuming a 43/57 split between public and private actors.

A further consequence of this investment in investigation is the generation of jobs and long-term employment in contaminated site investigation and remediation (e.g. environmental consultants, geologists, remediation engineers, etc.). it is estimated that this could lead to a direct, additional employment effect of around 26,200 FTEs on an ongoing basis. There will also be additional indirect and induced employment effects as the impacts ripple through the economy (e.g. increased attractiveness of areas with remediated land). Although more uncertain than the estimate of direct effects, an estimate of the total employment effects is around 35,200 additional FTE jobs on an ongoing basis.

As noted above, identification of CS is a necessary pre-requisite to remediation. The identification of CS will not have any associated direct adjustment costs (Indicator 'Adjustment costs': Options 2/3/4 '0') – the costs of the remediation actions themselves are captured under REM and hence not counted again here.

The distribution of impacts across Member States may vary. Under Option 2, additional burdens would be more significant for Member States which currently have more limited identification and investigation systems. For example, 4 Member States (Greece, Malta, Poland, and Portugal) only had inventories in preparation, and 3 Member States (Croatia, Romania, and Slovenia) did not have official inventories at the time data was collected for the 2018 JRC report.[994] Benefits for these Member States would be higher. Member States that are performing and progressing well, should be able to continue on the same pathway as long as this allows them to achieve the zero pollution ambition by 2050. The distributional effect of all options is somewhat uncertain, but given the obligation to identify CS is common across all options, so too will any distributional effect (Indicator 'Distribution of costs and benefits': Options 2/3/4 '-'). There may also be a trend in the location of stakeholders affected. Many (but not all) CS are likely to be located in urban or semi-urban locations. As such, where the costs of identification (and in particular risk assessment) are shared with private actors, many will fall in the first instance in these areas. That said, in many cases a single CS will be one site in a wider portfolio, and the

[992] JRC (2018) p. 60
[993] JRC (2018) p. 78
[994] JRC (2018) p. 45.

costs will accrue to the over-arching business owner, who may spread these costs across its portfolio.

In terms of coherency with other legislation, several potential synergies were identified. Some of the 'risk activities' susceptible of contaminating a site are already recognised under the Industrial Emissions Directive and the Environmental Liability Directive. Risk acceptability thresholds exist in water and air legislation (Water Framework Directive and its daughter Directives, Drinking Water Directive, Ambient Air Quality Directive, amongst others), therefore establishment of threshold values for soil could bring coherence, although the thresholds for soil would differ. For all options, no incoherencies with existing EU legislation were identified.

Across the building blocks, Option 4 may be slightly more consistent with all options under other building blocks in comparison to Options 2 and 3. For example, even where all CS are checked against EU limit values under Option 4, this could still align with Option 2 under REM where priorities (e.g. timing, budget allocation, etc.) for remediation are left to Member States. Whereas allowing Member States to identify risk acceptability criteria for the assessment of sites (DEF Option 2 and 3) would not be as synergistic with a subsequent remediation programme where the prioritisation for remediation is set at EU-level (REM Option 4), as the priorities for remediation may not be fully consistent with the acceptability criteria selected across all Member States.

Options 3 and 4 might result in some incoherencies with existing Member State provisions. Under Options 3, this is expected to be minimal, as the common criteria would still allow flexibility. The main impact may be for Member States which need to move from soil screening value investigation approaches to risk-based investigation approaches (which is expected to be a small number of Member States). Option 4 is more prescriptive, so would likely incur greater impacts in terms of efforts required by Member States to change their existing investigation approaches, particularly as many Member States currently apply site-specific risk-based approaches.

4.3 Summary of stakeholder views

In response to the OPC, there was a strong agreement across all stakeholder types that there should be legal obligations for Member States to identify contaminated sites that pose a significant risk to human health and the environment. 89% of all respondents 'totally agreed' this obligation should be put in place, with a further 8% 'somewhat agreeing'. Furthermore, 'totally agree' was the most frequent response across all stakeholder types. There was also strong agreement that the information and environmental data from a registry of contaminated sites be publicly available – in this case 85% 'totally agreed' with 10% 'somewhat agree'. 'Totally agree' was the most common response across the majority of stakeholder types with the exception of business associations and trade unions, in which case 'somewhat agree' was most common.

Between the options, Member States have indicated a general preference to retain flexibility to some degree, tending to favour more so Options 2 and 3. Stakeholders broadly favoured risk-based approaches given the need to consider site-specific conditions, and how they differ between sites, in the assessment of risk.

Several stakeholders reported in consultation that common principles under Option 3 should require risk assessments to be site-specific and risk-based. But stakeholders showed a variance in opinion around specifically what any common EU guiding principles for the risk assessment procedure should contain. For instance, Austria stated that harmonising risk assessment common principles should be established only as general guidance for implementation by Member States at a later stage. Norway described the suitability of creating a minimum list of soil contaminants. Germany described the usefulness of a tiered approach for site identification, with defined thresholds for different sites and uses defined. The Netherlands proposed uniform toxic data for human and the environment, and to stimulate knowledge on micro-plastics, POPs and Substances of very high concern (SVHCs); paired with a schedule for an action plan for Member States. A mining company also suggested that assessments should take into account the respective or intended land use.

On the other hand, some Member States noted that they should not be restricted to the analysis of certain substances and should be able to define their own limit values. Whereas others preferred Option 2, as they specified that risk assessment should be left entirely to Member States to avoid duplication of efforts with existing processes.

Some stakeholders highlighted the challenge in defining common principles – e.g. defining a minimum list of contaminants would be challenging because of differences between Member States industrial activities and because of the continually growing number of potential contaminants.

4.4 Findings

In summary, the options under this building block aim to facilitate the implementation of remediation measures on contaminated sites under the REM building block by requiring Member States to identify, investigate, and risk assess all (potentially) contaminated sites in the EU and to make this information publicly available in the form of contaminated site inventories. Hence all options would form a critical basis for the REM building block and deliver a significant improvement to the information, data and governance around soil health. The options vary in terms of the approach to assessing risk on CS, which then may have a consequence for which and how many sites are remediated under REM. ***Option 3 appears to be the preferred option*** as it best mitigates the opposing risks of a continuing variance in ambition to remediate CS across Member States (which could be a significant risk under Option 2), and challenges that a non-risk based approach under Option 4 would drive levels of risk reduction and remediation activity beyond an efficient level. Although there is still some risk of inconsistency in efforts between Member States under Option 3, this would be reduced in comparison to Option 2 due to the common principles. In comparison to Option 4, Option 3 would likely be better (scientifically) as the flexibility afforded to Member States should allow assessment methods to take into account differences in geographic factors, contaminants, and risks across Member States, which would not be addressed by a single common approach. The common principles set out by Option 3 could ensure that Member States reach minimum requirements for good practice in site identification, so that a higher proportion of sites needing remediation for the protection of human health and the environment can be identified and subsequently remediated.

Table 4-1: Overview of impacts

		Option 2	Option 3	Option 4
Effectiveness	**Impact on soil health**	(+)	(+)	(+)
	Information, data and common governance on soil health and	+++	+++	+++

	management			
	Transition to sustainable soil management and restoration	(+)	(+)	(+)
Efficiency	**Benefits**	+++	+++	+++
	Adjustment costs	---	---	---
	Administrative burden	---	---	---
	Distribution of costs and benefits	-	-	-
Coherence		+/-	+	+
Risks for implementation		---	--	---

5 ANALYSIS OF OPTIONS UNDER SOIL RESTORATION AND REMEDIATION (REST/REM)

5.1 Description of the option

This building block captures options for the application of restoration and remediation measures for unhealthy soils. Active restoration measures are crucial to return the 60-70% unhealthy soils in the EU to good condition and thus more resilient by 2050, and that protection, sustainable use and restoration of soils should become the norm. Remediation of contaminated sites is considered in this context as a form of soil restoration.

The principles of restoring soil health and preventing further degradation are implied in a number of existing EU legislations, however a specific obligation to restore unhealthy soils and guidance on what measures may achieve this are lacking. Some action is already being undertaken at Member State level, but again there are risks comprehensive restoration will not be achieved. Furthermore, there are no EU-wide provisions for remediating historically contaminated sites. While new contamination is prevented and addressed for some specific risk activities by wider EU legislation (e.g., the Industrial Emissions Directive, the Waste Framework Directive, and the Landfill Directive), much of the contamination affecting EU soils is from historic polluting activities or from illegal activities. This problem is addressed to some degree in national strategies and regulations, however, there is high variance in the level of commitment and activity to remediate across Member States.

Options 2, 3 and 4 under this block anchor the ‘vision’ of the Soil Strategy, that by 2050 all EU soil ecosystems should be in healthy condition, in the Soil Health Law. Moreover, for soil contamination, the zero pollution ambition applies, notably that by 2050 soil contamination should be reduced to levels no longer expected to pose risks for human health and the environment. Similar to other environmental legislation, Member States should adopt programmes of measurest, and revise these plans periodically.

Building further on the identification of contaminated sites that require further action from building block DEF, Member States need to have in place a systematic approach to reduce and keep the risk of contaminated sites to acceptable levels, e.g. through risk reduction or soil remediation activities. Member States would also be obliged to report periodically on the progress made in achieving soil health.

The options differ according to the extent to which the delivery of these targets is harmonised at an EU-wide level, or left to Member States:

- ***Option 2***: Member States have complete flexibility regarding the restoration and remediation measures that they put in place, since there would be no obligation to develop programmes of measures. Prioritisation and planning of the risk reduction and remediation measures for contaminated sites is also left entirely to the Member States. Some categories of unhealthy soils can be derogated by Member States from the obligation to have all soils healthy by 2050, because it is not technically feasible or economically proportionate to restore them, for example where soils are sealed or heavily modified;[995] or soils that have in natural condition characteristics that could be considered as unhealthy.

- ***Option 3:*** The EU would define common minimum criteria for the content of the programmes of measures (e.g. present results of monitoring and assessment of soil health, indicative annex of restoration measures, report on legislative actions), but Member States would have flexibility in their restoration activities. Prioritisation and planning of the remediation measures for contaminated sites is left entirely to the Member States. Some categories of unhealthy soils can be derogated by Member States from the obligation to have all soils healthy by 2050 (the same as Option 2). Remediation would be favored over other risk reduction measures.
- ***Option 4***: The EU would fully harmonise the programmes of measures, with a stringent and extensive template that needs to be filled in. Member States should prioritise and plan the management and remediation of contaminated sites based on EU-wide common criteria and strict common intermediary targets for progress. No categories of unhealthy soils can be derogated from the obligation to have all soils healthy by 2050.

5.2 Discussion of the relative impacts, costs and benefits of the options

The targets defined under this building block place obligations directly on Member States to restore all unhealthy soils and remediate contaminated sites and provides a general objective for the other building blocks – this marks a significant improvement in the governance of soils. Furthermore, programmes of measures are an important tool to improve the exchange of information, and the governance at EU level. Regular reporting by Member States on the progress made also contributes to the development of the knowledge base and to benchmarking (Indicator 'Information, data and common governance on soil health and management': Options 2/3/4 '+++'). As noted, there is a strong link to the SSM building block as many SSM practices could contribute to the restoration of soils - because of this interaction, there will be overlap in the actions in response to the option selected under SSM and REST, and hence also the impacts, costs and benefits of these options.

Actions implemented to restore soil health will deliver significant environmental benefits, including: the restoration of the health of soil (e.g. the use of cover crops can benefit both the retention of nutrients and also the physical structure of soils); knock on effects to the quality of both water and air (e.g. restoration of the structure and porosity of soils will aid in the storage and infiltration of water, reducing standing surface water and therefore the risks of flooding, drought, and soil erosion); improving biodiversity (e.g. practices involving the principle of natural regeneration to achieve restoration of soils may confer further benefits for biodiversity by providing food sources and habitats for a variety of animal species), and climate change (e.g. achieving net-zero greenhouse gas emissions by 2050 relies on carbon removals through the restoration and better management of soils).

[995] Heavily modified soils" refer to soils where the provision of ecosystem services is almost completely hampered to such a degree that it is almost impossible to restore.

Remediating contaminated sites delivers a range of environmental benefits: it directly improves the quality of natural resources by reducing the presence of toxic chemicals in soils, groundwater and the food chain; it can have a positive impact on climate change mitigation in the medium to longer term (e.g. there is evidence that pollution reduces the capacity of soil to absorb carbon dioxide); and it reduces the negative impacts from toxic chemicals on the living environment, from impacts on individual species and populations to impacts on overall biodiversity. Although the underlying evidence base does not allow an assessment of the EU-wide environmental benefits of risk reduction activity, all options under the building block are still anticipated to deliver significant benefits in terms of improvements to soil health. Under this building block, all sites identified as contaminated and requiring further action will undergo remediation or risk reduction measures, but the order and the precise completion date vary. The number of sites that will require risk reduction measures in practice is highly uncertain –assuming there may be 166,000 sites requiring remediation, equating to around 6,600 sites per annum over a 25 year implementation period.

Under the Soil Health Law Intervention, it is expected that the rate of remediation would increase from an average of 3,500 sites per year to an average of 6,600 sites per year. The benefits from remediation are long lasting and regenerative so would be more than twice the magnitude of benefits from remediation under the baseline. In comparison, the costs of this intervention are mostly reflected by one-off costs, which would therefore also be twice the magnitude of costs under the baseline.

The implementation of restoration measures may also, in certain circumstances, deliver economic benefits for the landowner and/or manager where applied optimally. Illustration of such benefits can be found in example projects already undertaken, for example: a restoration project in the Emscher Industrial Park in Germany - an example of urban soil restoration - introduced new land management measures which led to restored natural habitats, regenerated brownfield sites and recreational areas that boosted the economy in the surrounding area;[996] the EU LIFE funded Living Bog Project in Ireland re-created 750 hectares of active raised bog, and improved 2,649 hectares of bog habitat; and the LIFE-funded LUNGS project in Lisbon, Portugal directly target restoring soil health through increasing resilience to soil erosion on 115 ha of land, and will increase carbon levels of soil (approx. 740 tons of CO_2 to be sequestered).

A transition towards healthy soils could also deliver social benefits, such as: improved social perception and the image of the farming and industrial sector,[997] improvement in land managers' well-being/work-life balance, improvement in safety, livelihood and infrastructure of communities living in these areas, and sustain growth of businesses in the surrounding areas, e.g. tourism, markets, infrastructure.[998]

Likewise, remediation of contaminated sites could also deliver economic and social benefits:

- The total value of avoided health impacts (from reduced human exposure to contaminants) cannot be calculated, but is assumed to be several billions of euros per year across the EU. Various studies have explored and highlighted the health risks of living close to contaminated sites. Communities with large numbers of brownfields have

[996] https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law/success-stories_en
[997] The Business Case for Investing in Soil Health
[998] Gómez, J.A. et al. (2021), Best Management Practices for optimized use of soil and water in agriculture

poorer health[999]. Closer residential proximity to contaminated sites is linked with higher rates of low-birth-weight infants.[1000] A range of contaminants with varied health effects are present in CSs distributed across the EU. Monetary estimations for individual substances are substantive (e.g. the EU health burden from lead and methylmercury has been estimated to be €47 billion annually, and the EU health burden from PBDEs has been estimated to be €10 billion annually from cognitive effects (note these estimates include exposure from sources other than CSs)), therefore the cumulative effects from the multitude of contaminants existing in EU soils are expective to be large.

- Regeneration of land value could lead to additional economic benefits of millions of euros per year. For example, remediation and repurposing of sites for agricultural use could lead to benefits of €11.9 million – €59.4 million per annum. Further economic benefits would be expected as remediating land can increase the attractiveness and economic value of areas surrounding the previously contaminated site.
- Ecosystem services from healthy soils (e.g. filtering contaminants and nutrients, hydrological control, water cycling, climate control, habitat provision, and raw material production) have monetary valuations between €20 euros and €5,000 euros per hectare, depending on the specific service. Given contamination prevents these ecosystem services, it is assumed that benefits could reach several hundreds of millions of euros per year by the end of the time horizon,
- Job creation would be expected from increasing the requirements to remediate contaminated sites, bringing positive social impacts.

The size of the benefits achieved will depend on a range of variables in each case. For example for restoration, this will include: how unhealthy the soil is initially, by what indicators are found to be unhealthy, what restoration measures are required and implemented and to what extent – these in turn will be driven by the definition of soil health descriptors and associated ranges. For remediation, the more sites that are identified as contaminated and requiring further action, the higher the costs of risk reduction measures. Given limitations in the underlying evidence base, it is not possible to quantify nor monetise the effects EU-wide. That said, estimates of the cost of inaction suggest that the benefits could be substantial: It has been estimated that halting and reversing current trends in soil degradation has the potential to create €1.2 trillion per year in economic benefits.[1001] Further to this, every €1 investment in land restoration brings an economic return of €8 to €38[1002] (noting that this will likely capture some benefits broader than restoration).

Comparing and distinguishing between the options is somewhat challenging. This will depend on a number of variables, including the common criteria for the programmes of measures and the prioritisation of remediation of contaminated sites, and the restoration measures and ordering of remediation in practice. That said, qualitative analysis implies that the size of the benefits achieved could vary across the options.

For restoration as a whole, it is anticipated that the potential benefit under Option 2 is less than that under Options 3 and 4 because without programmes of measures, there is a greater risk of variance in the content and ambition of these programmes. In contrast, the common criteria under Option 3, and complete harmonisation under Option 4 of the

[999] https://www.dur.ac.uk/news/newsitem/?itemno=20467
[1000] Baibergenova, A., Kudyakov, R., Zdeb, M., & Carpenter, D. O. (2003). Low birth weight and residential proximity to PCB-contaminated waste sites. Environmental health perspectives, 111(10), 1352-1357.
[1001] EC (2021), EU Soil Strategy for 2030
[1002] EC (2022), Nature Restoration Law Factsheet

programmes of measures mitigate this risk to a greater extent (Indicators ‘Impact on Soil Health’, ‘Transition to sustainable soil management and restoration’ and ‘Benefits’: Option 2 ‘++’, Options 3 and 4 ‘+++’), which is also reflected in a higher implementation risk (Indicator: Option 2 ‘---‘). That said, greater prescription also carries with it an implementation risk as to how far common content for a programmes of measures can be prescribed for the whole EU. This exercise would present a highly technical challenge and there is a risk that either this takes a significant time to develop, impacting on the timelines for implementation, and/or a common criteria is developed which is not universally applicable and risks driving detrimental or inefficient activities in certain districts (Indicator ‘Risks for implementation’: Option 4 ‘---‘). Option 3 somewhat mitigates this risk as a minimum set of common criteria for the programmes of measures the measures that Member States should put in place, would be established, assuming that these criteria are limited to those in which there is confidence that they can apply EU-wide (Indicator ‘Risks for implementation’: Option 3 ‘--‘).

For the remediation of CS, under Options 2 and 3, Member States are given the flexibility to prioritise the remediation of sites. The composition of every Member State’s CS and PCS has its own particular characteristics based on geographical, economic and historical reasons, which can be difficult, if not impossible, to harmonise. Thus, incorporating Member State and even site-specific parameters into the prioritisation would allow these specificities to be taken into account and could improve feasibility of the intervention. However, this flexibility also brings with it a risk of inconsistency in approach between Member States – for example some Member States may choose to prioritise uniquely based on cost, rather than a combination of cost and environmental or human health hazard. This could both delay the achievement of the most significant environmental and health benefits from this option (but also the costs), and leaving the most challenging sites until later also poses a risk as to whether remediation could be achieved within the timeframe presented. This could lead to an uneven playing field among Member States in terms of the timeline, as some could have a larger percentage and amount of costs under the list of cases susceptible to derogation from the obligation to achieve healthy soils by 2050. Option 4 would ensure greater EU harmonisation, establishing EU level prioritisation criteria, however this would represent a significant policy challenge given the variability of CS across Member States. It would provide a clear path for Member States to remediate sites, however, this could lead to undesirable results, where national and local specificities are not adequately taken into account. It would provide a level playing field for Member States but potentially also a less efficient solution.

Options 2 and 3 also allows derogations for specific sites where particular criteria are met. Again, the impact of this will depend on what criteria for derogation are set, and how many sites are granted a derogation. The presence of a derogation inherently reduces implementation risk for Member States and private actors under Options 2 and 3 for technical and economic reasons. However, not restoring unhealthy soils (which could include not remediating specific CS) would inherently reduce the environmental and human health benefits that could be achieved relative to Option 4, where no derogations would be allowed. Option 4 is therefore the most uncertain in terms of feasibility.

The adjustment costs of all options under the building block will be high as restoration and remediation activities will carry upfront and ongoing costs – these are likely to be one of the most significant impacts associated with the SHL package. The costs will be driven by which restoration practices are implemented in each Member State. Many SSM practices also contribute to soil restoration and as explored above, where such measures are implemented EU-wide the adjustment costs could be significant and partially overlap with SSM. 60-70% of soils is estimated to be unhealthy, meaning that a significant number of land managers may have to alter their current practices in order to restore their soils, and therefore incur costs. That said, there will be a significant overlap with the practices, associated costs and benefits of the measures implemented under the SSM building block – as such not all the costs of REST would be additional where options under these building blocks are implemented together. Furthermore, the that the 60-70% of land assessed as 'unhealthy' is currently underproviding ecosystem services – where this is improved, this has the potential to deliver huge economic benefits.

For remediation, the management of contaminated sites incurs costs through monitoring, risk management, and remediation activities. Remediation costs can range from €500 to €50 million per site. EY (2013) assume an average cost of €180,000 per site needing remediation, while the JRC (2018) reports a median cost of €124,000, and the EEA apply a cost of €100,000 per site (reflecting typical costs for "small" sites according to EY (2013)).

Assuming a time horizon of 25 years, the intervention could require an average remediation rate of 6,600 sites per year. This represents approximately twice the costs of the baseline (e.g. €1 billion per year (2023 prices) rather than €400 million per year, if an average remediation cost of €124,000 per site is assumed).

Following the logic underpinning the size of the benefits achieved above, the adjustment costs under Option 2 are anticipated to be slightly lower (although still large) than under Options 3 and 4, again because where flexibility is left to Member States there may be greater variance in effort between Member States, resulting in some implementing perhaps fewer measures (Indicator 'Adjustment costs': Options 2/3/4 '---'). Option 2 could result in less comprehensive identification of sites requiring remediation, which would lower remediation costs. Option 3 may be more proportional and effective if the EU minimum criteria result in better identification of contaminated sites needing remediation.

It is uncertain precisely where adjustment costs would fall as this will depend on the method of implementation in each Member State. The obligations to restore unhealthy soils and remediate CS will be placed on Member States in the first instance. That said, landowners and managers will have an important role in implementing restoration measures but only a proportion of the benefits could accrue to the private landowner or manager, positive returns may only emerge after several years and some measures may not deliver an economic return (Indicator 'Distribution of costs and benefits': Options 2/3/4 '--'). Remediation costs are likely to be distributed among the public administration, the private sector, and EU funding and would most effectively follow the polluter pays principle (Indicator 'Distribution of costs and benefits': Options 2/3/4 '+/--'): Historically, over 43% of expenditure on contaminated site management is from public budgets (Public authorities (and budgets)). This figure however varies by country: e.g., in Norway, nearly 90% of costs are borne by the private sector, while in the Czech Republic and Portugal, none of the costs are borne by the private sector. Given the significance of such costs, there may be important impacts for SMEs and on the sectoral competitiveness, trade, and investment flows of affected sectors as producers in non-EU countries would not be subject to the same costs.

There will also be a variance in costs and impacts between and within Member States. For example, those Member States that have a wider area of unhealthy soils and/or soils will require more extensive restoration action, and hence also costs. In addition, in some districts multiple restoration measures may be required, whereas additional activity may not be required in others. In addition, Member States who have made limited remediation progress so far (e.g. Greece, Ireland, Poland, Romania, and Slovenia) will face the highest costs. Overall, the provisions will ensure a fair distribution of spending on remediation, which has, to date, been unequally distributed between Member States. Finally, across stakeholder groups, there would be significant benefits for all the citizens, which would achieve health, food and water security for the present and subsequent generations.

There will also be important impacts for both rural and urban stakeholders: wider restoration measures are likely to predominantly impact rural areas as agricultural and forestry land represents a greater land area, soils are more actively managed and nutrients are applied in greater amounts – hence the costs (and benefits) of implementing these measures will also fall more so on rural areas. For remediation, many (but not all) CS are deemed likely to be located in urban or semi-urban locations as such many of the costs of identification and remediation actions may fall in the first instance in these areas. That said, in many cases the costs of remediating a single CS will be spread by the site owner across a wider business portfolio. Some of the benefits of remediation are more likely to accrue to those working on CS and local communities, and hence urban and semi-urban areas (e.g. avoided health impacts from exposure to hazardous substances). Some will accrue to the private sector owners e.g. increase in value of restored land (although as for the costs, these might not necessarily fall to urban areas). There will also be other benefits for broader businesses locally – e.g. a reduction in costs of treatment of surface water, groundwater or drinking water contaminated through the soil.

There will be administrative burdens associated with the options. These are anticipated to be moderate in particular compared to options under the other building blocks (Indicator ‘Administrative burden’: ‘--‘). These are presented in the table below. The most significant burden is anticipated to be the costs associated with the obligation for Member States to adopt programmes of measures to achieve restoration of unhealthy soils in scope by 2050, and, every 5 years thereafter, to report on its attainment of targets and to revise it accordingly if needed. Upfront burden is marginally higher for Options 2 and 3 as all 27 Member States must define a prioritisation criteria, and for Option 2 and 3 associated with the ongoing management of the derogations process.

Table 5-1: REST Option administrative burdens (EC = European Commission, MS = Member States; no administrative burden for any other actors – e.g. businesses nor citizens – has been identified) – further information on the method to calculating administrative burden for any other actors – e.g. businesses nor citizens – has been identified) – further information on the method to calculating administrative burdens can be found in annex 9 section 6

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-off costs	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)			(EUR)	(EUR pa)
Option 2	4,100	74,000	541,000	1,670,000	-	270,000	551,000	1,940,000
Option 3	29,000	98,000	551,000	1,670,000	-	270,000	581,000	1,940,000
Option 4	50,000	98,000	500,000	1,400,000	-	-	547,000	1,400,000

With respect to coherence, all options are broadly coherent with options under other building blocks. That said, Option 4 could be seen to be slightly less coherent with options under other building blocks where greater flexibility is left to Member States, such as SHSD (Indicator 'coherence': Options 2 and 3 '+', Option 4 '+/-'). Furthermore, Option 4 carries with it a greater risk of overlap with other legislation, in particular the CAP – where certain practices are mandated or prohibited, both the SHL and CAP would apply separately to the same areas of land, which was highlighted by some stakeholders as an added complexity and burden on farmers to avoid.

5.3 Summary of stakeholder views

Mandating the achievement of healthy soils received strong support amongst stakeholders. In response to the OPC, 86% of respondents 'totally agreed' that the future EU Soil Health Law set obligations for Member States to achieve healthy soils by 2050. This was the most common response across all respondents (with the exception only of Business Associations, who were split fairly equally across all possible responses). Stakeholders also highlighted more general trends and interest in restoration practices. For example, some revealed that interest in specifically rewetting of drained peatlands is increasing recently, indicating the support for soil restoration.

Stakeholders highlighted that costs of restoration activities have proven a barrier historically, but also noted that costs of restoration could be offset by economic instruments and positive incentives such as quality benchmarks, true pricing, and locally produced products. Stakeholders also highlighted that stimulating knowledge sharing will be integral for ensuring restoration can take place within a reasonable timeframe, implying that existing education and knowledge may present a barrier to uptake of restoration measures.

With respect to remediation of CS specifically, in response to the OPC, there was a strong agreement across all stakeholder types that there should be legal obligations for Member States to remediate sites identified as contaminated and posing a significant risk to human health and the environment. 81% of all respondents 'totally agreed' this obligation should be put in place, with a further 14% 'somewhat agreeing'. Furthermore, 'totally agree' was the most frequent response across all stakeholder types. In addition, the majority of OPC respondents also 'totally agreed; that Member States should be required, within a legally-binding time frame, to establish and implement a national plan to remediate sites that represent a significant risk to human health or the environment – 72% 'totally agreed' with this obligation, with a further '18%' somewhat agreeing.

Stakeholders highlighted key challenges associated with the costs of remediation activities. Member State stakeholders reported that remediation costs are usually superior to the monetary value of the land, and hence costs present a barrier to implementation. Furthermore, stakeholders also reflected that costs portray a range with huge variability, and hence are very challenging to estimates.

Member State authorities' views on derogations were uncertain. Due to the impossibility of predicting the evolution of remediation technologies for 2050, they could not estimate if it could be possible to have all CS remediated by this time. Moreover, some noted that new polluted areas and pollutants might be uncovered across time, making the 2050 goal unattainable. The few stakeholders that did comment on the potential for derogations highlighted that there could be some benefit in having a derogation as in some cases, the use of land may not be compatible with remediation, hence a derogation would allow flexibility such that remediation can occur when the land-use changes.

Generally, Member States' views favoured a risk-based approach, where prioritisation and planning are left in charge of national and regional authorities (Option 2 and Option 3). Some Member States were open to an EU common approach (Option 3) as long as it only sets minimum requirements that allow each Member State to independently consider site-specific risks and circumstances. On the other hand, other Member States welcomed a comprehensive EU common approach (Option 4).

5.4 Findings

Together, the options under REST and REM will be the most impactful of the SHL package. They will deliver the improvements in soil health and remediation which is the core objective of the SHL (albeit with an overlap with SSM in terms of the measures implemented and the associated impacts). These options will deliver significant environmental benefits, and have the potential to deliver economic benefits also where measures are optimally applied, but will also incur significant adjustment costs (and moderate administrative burden to do so). At this stage it is uncertain where the costs will fall but there could be a significant distributional effect, both for specific Member States where they have a greater number of unhealthy districts or CS, and within Member States where different levels of activity are required between different districts. ***Option 3 appears to present the best option*** **for restoration. Option 2 is considered as the preferred option for remediation.**

Table 5-2: Overview of impacts

		Option 2	Option 3	Option 4
Effectiveness	**Impact on soil health**	++	+++	+++
	Information, data and common governance on soil health and management	+++	+++	+++
	Transition to sustainable soil management and restoration	++	+++	+++
Efficiency	**Benefits**	++	+++	+++
	Adjustment costs	---	---	---
	Administrative burden	--	--	--
	Distribution of costs and benefits	+/--	+/--	+/--
Coherence		+	+	+/-
Risks for implementation		---	--	---

6 Analysis of Options under Land-take (LATA)

6.1 Description of the options

Land take can contribute to unhealthy soils as practices such as soil sealing lead to irreversible loss of all soil ecosystem services. Currently, the definition of land-take and the processes it involves, in addition to assessment methodologies, are not standardised between Member States. Given limitations of EU-level monitoring, national data sources are often utilised to gather more detailed data, yet the definitions and assessment methodologies vary significantly. These inconsistencies can inhibit the development of comparable data and enable an accurate oversight of land take trends at the EU-level.

LATA involves establishing a definition of 'net land take', (and as such is closely linked to SHSD whereby land take is considered as a descriptor to define soil health) but with no binding target attached. The proposed definition is contained in the following Information Box. This common EU definition would provide a degree of harmonisation to the monitoring of land take, while leaving the needed flexibility to Member States to define precisely which surfaces can be identified as artificial and which not within the given EU frame.

Information Box – Proposed EU-wide definition of net land take

Land take could be defined as the conversion of natural and semi-natural land into artificial land development, using soil as a platform for urban settlements and infrastructure, as a source of raw material or as archive for historic and geological patrimony, at the expense of the capacity of soils to provide the natural ecosystem services (provision of biomass, water and nutrients cycling, basis for biodiversity and carbon storage).

As such, land take would correspond to the change in land use and/or land cover from: forests, grassland, agricultural land, shrub lands, natural bare soils, wetlands, green urban areas or other natural or semi-natural ecosystems, into: sealed soils, buildings and infrastructures (including logistic hubs and sport facilities), artificial surfaces, dump sites, mined areas, areas of storage of materials or areas reserved for the archive of geological, geomorphological and archaeological heritage.

Conversely, land renaturation would be the reconversion from artificial areas to natural and semi-natural land development allowing for the re-establishment of soil's capacity to provide the natural ecosystem services. Finally, "net land take" would be equal to the land take area minus the land renaturation area.

It also involves placing an obligation on Member States to monitor (and report on): land take as defined at EU-level and progress towards achieving the targets set voluntarily at national level to reduce net land take by 2030 and to achieve no net land take by 2050; its related features (such as soil sealing, land renaturation, re-use of artificial land); its environmental impacts (in terms of related loss and restoration of ecosystem services); and the actions taken to achieve national targets of land take reduction. The monitoring requirements would be complementary to the adoption of an option under the MON building block, whereby (net) land take monitoring at EU level by EEA would act as an oversight system.

6.2 Discussion of the relative impacts, costs and benefits of the options

Given the importance of land take impacts on soil health, formulating a common definition for EU usage would present a clear benefit in terms of furthering a common understanding of what constitutes good soil health, and facilitate the gathering of comparable data and information around the current state of soil health in the EU. Given that some Member States have already established quantitative targets within national policy to tackle land take, an EU-level definition would assist in refining approaches across the EU to ultimately ensure a level playing-field in assessing any progress towards 'no net land take' by 2050. Furthermore, establishing an obligation for all Member States to monitor and report (net) land take would also present a clear benefit for improving the availability of comparable data and information around the current state of soil health in the EU (Indicators 'Information, data and common governance on soil health and management' and 'Benefits': '+'). In the absence of these options, it will be challenging to robustly track progress against the EU's 'no net land take by 2050' target.

Although LATA will not deliver any direct environmental and social benefits (Indicators 'Impact on soil health' and 'Transition to sustainable soil management and restoration':

‘(+)’), it is an important facilitating measure for subsequent action at national level around land take. There are synergistic linkages to other options. Certain forms of land take, namely soil sealing, can lead to complete loss of soil ecosystem services, degrading overall soil health. This links to SHSD and MON, and it could be reasonable to include (net) land take as part of a wider set of indicators defining good health for soils, and as a parameter that should be monitored (Indicator ‘Coherence’: ‘+’).

LATA would not impose direct adjustment costs (Indicator: ‘0’). That said, the option would imply a small additional upfront administrative burden and a moderate ongoing burden (relative to options under other building blocks) as summarised in the table below. This additional burden will mostly fall on Member States, associated with the upfront and ongoing costs of monitoring land-take. Costs to Member States will depend on definition of land-take – Member States would incur costs to establish monitoring networks, compile information and report. One off costs would be incurred to establish baseline land-take (Indicator ‘Administrative burden’: ‘--‘).

Table 6-1: LATA Option administrative burdens (EC = European Commission, MS = Member States; no administrative burden for any other actors – e.g. businesses nor citizens – has been identified) – further information on the method to calculating administrative burdens can be found in annex 9 section 6

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
Total	21,000	-	366,000	3,600,000	387,000	3,600,000

A transition cost could be expected for those Member States who already monitor land take, though this would be related to the potential changes in monitoring procedures, relevant to LATA 2. Where Member States have existing systems, or where they can access EEA or Copernicus services, costs may in fact be lower relative to other Member States (and significantly lower than those quantified in this analysis). If Member States need to undertake additional testing to characterise the quality of restored land, this could lead to higher costs (Indicator ‘Distribution of costs and benefits’: ‘-‘). LATA aims to facilitate a solution to the pressure of land take and soil sealing, which is predominantly an issue in urban and semi-urban areas. However, given this only places an obligation to define and monitor this threat, the direct impact on urban communities will be negligible.

The key risk for this option is the development of the definition itself, in particular whether a definition can be developed that is widely understandable and commonly applicable in all Member States. Depending on the scope of the definition, any specific details, such as the outlined potential inclusion of ‘artificial surfaces’, could potentially require more extensive consultations to refine the definition and implement through comitology (Indicator ‘Risks for implementation’: ‘-‘).

6.3 Summary of stakeholder views

In response to the OPC, there was a strong agreement across all stakeholder types that there should be obligations for Member States to monitor and report on the progress towards the EU objective of "no net land take" by 2050 (although noting that the overall support for such an obligation was marginally less strong relative to other proposed obligations). 79% of all respondents 'totally agreed' this obligation should be put in place, with a further 13% 'somewhat agreeing'. Responses to the OPC on particular aspects to be monitored relating to land take showed high support (i.e. responded 'totally agree') to all listed indicators: soil sealing (72%, n=977); land take (73%, n= 991); land recycling (56%, n=752) and land fragmentation (50%, n=671). In relation to the scope of potential monitoring procedures, stakeholders stated a greater preference for the monitoring of soils consumed for commercial activities/ logistics (69%, n=937 'totally agree') and airports, roads and carbon mines (70%, n=948 'totally agree') than soils consumed for renewable energies (55%, n=748 'totally agree', 25%, n=344 'somewhat agree').

Aside from the need to monitor and report on land-take, opinion was more mixed on meeting land take targets. Member States which experience high population densities or high population growth suggested that 'zero net land take' targets are infeasible. Furthermore Member States noted that a balance between economic development and other competing demands with land take (such as the location of businesses) needs to be considered, and harmonised definitions of soil artificialisation and degrees of naturalness would be required in order to develop robust indicators and limit excessive administrative (monitoring) burden. Linked to artificialisation, it was noted that it would be essential to acknowledge that zero net land take could still result in soil ecosystem service loss as renaturalisation may only result in partial soil restoration.

6.4 Findings

Implementing a definition and monitoring of land-take could deliver tangible improvements in the information, data and common governance of soil health. This would significantly work towards the standardisation and alignment of the definition of land-take itself and the processes it involves, in addition to assessment methodologies, between Member States, and better facilitate the development of comparable data and enable an accurate oversight of land take trends at the EU-level. This option would pose an additional, medium administrative burden but (although it is challenging to directly compare), it is anticipated that the benefits of this measure would outweigh the costs. In summary, ***LATA could be complementary and add value alongside a broader package of options under a SHL*** – these options could sit either within or separate to the other building blocks (i.e. definition of land take could be incorporated into SHSD, and monitoring into MON).

Table 6-2: Overview of impacts

Effectiveness	**Impact on soil health**	(+)
	Information, data and common governance on soil health and management	+
	Transition to sustainable soil management and restoration	(+)
Efficiency	**Overall benefits**	+
	Adjustment costs	**0**
	Administrative burden	--
	Distribution of costs and benefits	-

Coherence	**Complementarity/ alignment with other policy domains**	+
Implementation risks		-

7 ANALYSIS OF OPTIONS UNDER SOIL HEALTH CERTIFICATES (CERT)

7.1 Description of the options

Soils in the EU are unhealthy and continue to degrade. This is partly driven by market failures around land transactions. Namely, buyers of land are not aware of soil health and cannot integrate restoration costs into land transactions, and – linked to this – land prices do not reflect externalities and cost of degradation. Although soil health is to some extent already regulated in certain Directives (e.g., the IED and the ELD), at EU level no policy exists on the provision of information on soil health when land changes ownership. The only Member States which are known to have a soil certification system in place are Belgium (with slightly different systems in the Flanders, Wallonia and Brussels regions) and Finland. In these cases, the requirements placed on sellers for information provision relate to soil pollution, not soil health more widely.

Two options were considered under this building block both of which considered the establishment of voluntary certificates providing information to land buyers on the status and key characteristics of soil in the site they intend to purchase. Certificates could be used also as part of the transaction of land between landowner and tenant, allowing the landowner to track any degradation that occurs over the tenancy period. The two options vary in the information they contain and their coverage of transactions: CERT1 focuses on providing information on the contamination status of soil in transactions concerning the sale of land for all properties in the EU (except on private urban properties where no contamination is suspected); and CERT2 establishes certifications providing information on the overall health of soils in transactions involving forestry and agricultural land, also including urban land where food is grown.

7.2 Discussion of the relative impacts, costs and benefits of the options

The direct benefit of both certification options is to improve the information, data and governance around soil health (Indicators 'Information, data and common governance on soil health and management' and 'Benefits': CERT1+2 '+'). Both options will increase awareness of soil health in landowners and prospective buyers as this information becomes a visible part of the process and documentation around land transactions. The measures will also have an indirect impact on soil health (Indicators 'Impact on soil health' and 'Transition to sustainable soil management and restoration': CERT1+2 '(+)') where landowners remediate land in order to obtain a certificate showing it is non contaminated (CERT1), or restore soil to good health (CERT2), and/or landowners take additional action to maintain a non-contaminated status or good health status throughout their tenure in order to maintain or improve the value of the land. Landowners of uncontaminated land or healthy soils in theory would see the value of their land increase, relative to those who own contaminated land or land with unhealthy soil. The identification of contaminated sites, even without remediation, is expected to positively impact public health and safety because activities on the land will be influenced by the knowledge of its contamination status. This measure is expected to have a small, direct positive effect on employment associated with: the IT services needed to set up and maintain the repositories in all EU Member States (as seen in the Belgium examples), as well as businesses specialised in investigation and remediation of contaminated sites, as an increasing number of people will request their services.

However, the benefit of this measure is not anticipated to be as significant as that achieved under other building blocks and is somewhat uncertain for several reasons. First, for both CERT1 and 2, the voluntary nature of the system may affect its uptake – a limited uptake of certificates will inherently limit the benefits such an option can deliver. In the absence of certificate, where a piece of land is by default declared as 'contaminated' or 'unhealthy' this would provide an incentive to the landowner, in particular where the value or price of land is affected. But for this incentive to materialise in practice, this would require land purchasers to be aware of and demand certificates as part of the land transaction, and to alter their behaviour in response. Second, the impact of the scheme is inherently limited by the level and frequency of land transactions – the information provision and any subsequent price and behavioural response will only be evident during the sale and purchase of the land. Some land types, in particular some which may be key targets of certifications (e.g. agricultural and forestry sites under CERT2) may only change hands very infrequently, thus limiting the potential impact of the certificates. Third, the remediation of contaminated land and the restoration of unhealthy soils are already mandated under other building blocks – i.e. REM/REST. Hence there will be overlap in the environmental benefit achieved with these other building blocks - it may be that certificates drive action sooner in some cases where land transactions occur prior to the wider remediation or restoration programme and/or that the onus is placed immediately on the landowner, although this runs counter to the risk under the second point above.

In addition, both options carry specific risks. In the case of CERT1, the implementation of a scheme which subsequently affects all current landowners may place a burden on some who were not responsible for the original contamination of the site they own – for example, where a landowner purchased a piece of land for which information on contamination was unavailable at their point of purchase. In these cases, the present landowner will face a cost for pollution they have not caused (Indicator 'risks for implementation': CERT1 '-'). For CERT2, as noted under SHSD, defining good soil health is a technically challenging task, and the thresholds for soil health and interpretation in the certificates would need to be technically robust, in particular where this would have an impact on the value of a landowner's assets. Furthermore, assessing soil health (in particular where this requires additional testing), may impact on the speed of the transaction, and hence in turn on the willingness of parties to attain this voluntary certificate. Finally, the added value of a certificate for general soil health is also challenged by the fact that some elements of soil health (e.g. in particular those which impact on the productivity of agricultural or forest land) would likely be part of existing due diligence undertaken by prospective purchasers around land transactions (Indicator 'Risks for implementation': CERT2 '--').

There are strong links between both CERT measures and options under other building blocks, in particular DEF (CERT1) and MON (CERT2). Under DEF, Member States will have an obligation to identify all potentially contaminated sites', and all 'contaminated sites' and all 'sites requiring remediation', and to publish these lists in a public register. This will provide a valuable source for the information to be contained in the certificates – where these registers are comprehensive and carry the level of granularity applicable to the parcels of land being bought and sold, costs for additional testing under CERT1 are minimised. Where additional testing is required, this information could then form part of the public register, hence providing an additional benefit under REM (Indicator

‘Coherence’: CERT1 ‘+’). Likewise, under MON, Member States will have an obligation to monitor in-situ and report on current status of soil health every 5 years, for all 'soil districts' and for all soil descriptors of the 'minimum list'. However, it is deemed less likely that the data gathered under MON will be of sufficient granularity that it can be readily used as part of a transaction around a given piece of land under CERT2. Furthermore, the requirement to monitor only every 5 years may call into question the applicability of data to be used in a certificate where this was 4-5 years old at the point of transaction. As such, it is anticipated that landowners would be required to undertake testing at their own expense to attain the necessary information to contain in the certificate, implying a reasonable adjustment cost. Given this is the case, this then also increases the risk that landowners would be unwilling to take up such voluntary certificates as part of the transaction. That said, again where additional testing is undertaken, where this can feedback into the overarching monitoring programme put in place by Member States, this will deliver a complementary benefit to MON (Indicator ‘Coherence’: CERT2 ‘+’).

Both options will also carry other administrative costs (other than the costs associated with testing) - estimates of which are contained in the following table (alongside the costs for additional testing, which are assumed to be zero for CERT1 where implemented alongside DEF, but significant for CERT2). The EC would bear some administrative costs associated with the time needed to set up guidelines and provide guidance to Member States. That said, the largest administrative burdens would fall on Member States who would incur several costs, including: designing and developing the policy framework (content of certificate, format, etc.); setting up and managing a database containing information needed for the Certificate to function (IT development, logistics to log all data onto the platform, ongoing maintenance costs); and reporting costs (Indicator ‘Administrative Costs’: CERT1+2 ‘---‘). The costs estimates made are based on the costs reported by the small sample of Member States who have comparable schemes already in place – in fact these schemes have demonstrated that even though there is a burden on public authorities, this can be recouped effectively through charging for certificates to be issued.

Table 7-1: CERT Option administrative burdens (EC = European Commission, MS = Member States) – further information on the method to calculating administrative burdens can be found in annex 9 section 6

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-off costs	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
CERT1	19,000	-	3,400,000	7,500,000	-	-	3,400,000	7,500,000
CERT2	19,000	-	3,400,000	7,500,000	-	33,000,000	3,400,000	41,000,000

A small positive effect on distribution of costs and benefits is expected as these options will influence the price of a property based on soil contamination or soil health, ensuring the polluter is financially penalised and does not pass on the contaminated soil to an unaware buyer (Indicator ‘Distribution of costs and benefits’: CERT1+2 ‘+’).

7.3 Summary of stakeholder views

When engaged, stakeholders were generally supportive of the introduction of such a measure (12 of 18 respondents to the call for evidence, 4 of 5 Member State authorities that commented, with the key hesitation being from a Member State who already has such a system in place). Rather than criticising the measure, some Member State public authorities provided suggestions on how the option could be best designed (e.g., comments on for which transaction a certificate could be required, how to define potentially contaminated sites that would require testing, etc.).

More than three quarters of OPC respondents (n=4411; 76%) who replied to a question on whether there should be legal obligations for Member States to set mechanism informing the buyer about the health of the soil when land is sold “totally agreed” with this measure, and a further 17% (n=988) “somewhat agreed”, highlighting a strong support for this measure. The stakeholder groups which supported this measure the least were business associations and trade unions (respectively 41% and 29% totally or somewhat disagreed with the measure). Moreover, 58% (n=3105) preferred this measure to be implemented via an official and mandatory “certificate” on soil health, with a further 37% favouring consulting a website with official soil health information on all land parcels. These results highlight that a majority of OPC respondents highly supported this measure and believed it would be an effective instrument to achieve healthy soils.

That said, some stakeholders raised questions around the usefulness of a soil health certificate. Some noted that farmers that practice sustainable agriculture are already rewarded by the market for higher prices for their land and/or a greater willingness to rent land from them.

7.4 Findings

In summary, both options would in theory provide small benefits around the information, data and governance of soil contamination and health as this information is placed at the centre of land transactions. A certificate could increase awareness on soil health and could have a small positive impact on the transition to sustainable soil management and restoration, and on soil health.

That said, there are several risks around CERT2 which could impact on its effectiveness, including that: significant additional testing could be required with an associated cost as monitoring mandated under MON may not be sufficiently granular– this could impact on the timeframe for transactions and uptake; prospective buyers of agricultural and forestry land are likely to undertake a certain level of due diligence as part of current transactions around elements related to soil health (in particular related to productivity), undermining the additional value of CERT2; and the effect will be inherently curtailed by the relatively slow level of transactions for agricultural and forest land.

For CERT 1, Certificates may not necessarily have a large, direct, additional environmental effect but it may help to ensure that existing landowners of contaminated land are unable to sell their land to unknowing buyers and helps to implement the polluter pays principle. A small positive effect on distribution of costs and benefits is expected as this measure will influence the price of a property based on soil contamination, ensuring the polluter is financially penalised and does not pass on the contaminated soil to an unaware buyer. However, a small negative implementation risk exists as the burden of legacy issues is placed on the current owner. Furthermore, the administrative burden of setting up and maintaining an EU-wide certification scheme are large and there is uncertainty around the added value of a certificate when information of soil health would have to be made as much as possible publicly available online and the additionality of any benefits given the general obligation to remediate CS under building block REST/REM. It would make sense to first optimise and improve the availability and knowledge on soil health, e.g. through building block 2 on monitoring, before establishing a heavy system of soil health certificates.

Hence ***a certification option is not carried through to the preferred option.***

Table 7-2: Overview of impacts

		CERT1	CERT2
Effectiveness	**Impact on soil health**	**(+)**	(+)
	Information, data and common governance on soil health and management	+	+
	Transition to sustainable soil management and restoration	**(+)**	(+)
Efficiency	**Overall benefits**	+	+
	Adjustment costs	**0**	0
	Administrative burden	---	---
	Distribution of costs and benefits	+	+
Coherence		+	+
Implementation risks		-	--

8 ANALYSIS OF OPTIONS UNDER SOIL PASSPORT (PASS)

8.1 Description of the options

One of the main drivers impacting soil health is the increasing rate of land-use change, which consequently leads to significant quantities of soil being excavated. Excavating soils is necessary for construction projects like water and sewer piping, repairing foundations, power line construction or other structural construction work. The soils extracted (both clean and contaminated) from these activities are one of the largest sources of waste produced across Europe in volume.[1003] No legislation exists at EU-level to encourage the re-use of excavated soils. Currently, excavated soils are considered to be waste under the Waste Framework Directive and are therefore often disposed of in

[1003] https://www.euractiv.com/section/circular-economy/news/excavated-soils-the-biggest-source-of-waste-youve-never-heard-of
[1003] Except when the soil is uncontaminated and excavated in the course of construction and if it is certain that the material will be used again on the excavation site
[1003] Reactive nitrogen includes nitrate, ammonium and ammonia, gaseous nitrogen oxides, nitrous oxide and many other inorganic and organic nitrogen forms.
[1003] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en
[1003] https://www.frontiersin.org/articles/10.3389/frsus.2021.658231/full
[1003] https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_6566
[1003] Measures included; advisory services for farmers, recommendations to MS on nutrient management, action plan at EU level, national/regional actions plans, legally binding fertilization rates for the main crops, adapted to regional pedo-climatic conditions, legally binding targets at EU level, legally binding targets at national/regional level and continue funding research and innovation actions to address safe and environmentally sound solutions.
[1003] https://www.wbcsd.org/contentwbc/download/6149/85658/1
[1003] https://www.sciencedirect.com/science/article/pii/S1002016017603060
[1003] Milieu (2017) The Study for the strategy for a non-toxic environment of the 7th Environment Action Programme Final Report, EC, DG Environment
[1003] Trasande, et al. (2016). Burden of disease and costs of exposure to endocrine disrupting chemicals in the European Union: an updated analysis. Andrology, 4(4), 565–572.
[1003] Amec Foster Wheeler et al. (2017) Study on the cumulative health and environmental benefits of chemical legislation. European Commission DG Environment.
Occurrence is reported in data available through the JRC ESDAC - Soil Contamination - ESDAC - European Commission (europa.eu)

landfills.[1004] At Member State level some countries have introduced legislation targeting the reusage of excavated soils, for example, the Netherlands, and Flanders have legislations in place that follow the standstill and fit-for-use principle (i.e. where excavated soil cannot be re-used if this would result in the deterioration of the environmental situation or an increased risk for human health; and excavated soils can only be reused when its quality is suitable or fit for the function or land use on the receiving site. Besides this, all existing national and regional schemes use a traceability system which requires excavated soils above a certain volume to be reported to a national register or a soil management organisation.

Two options are considered: the first policy option (PASS 1) refers to an establishment of a common obligation for Member States to put in place a system that monitors and traces excavated soils. This would require a procedure to notify excavation, transport, or application of soils and a system reflecting quality would require prior sampling and analysis of the excavated soil to ensure proper treatment of excavated soil. Flexibility around the means of implementation and of achieving the proper treatment would remain with Member States. The second (PASS2) would establish a common, digital soil passport with technical features defined at EU level to ensure traceability and reusability of excavated soils (essentially a facilitating measure to complement PASS1). The passport should reflect the quantity and quality of the excavated soil to ensure that it is transported, treated or reused safely elsewhere.

8.2 Discussion of the relative impacts, costs and benefits of the options

With regards to effectiveness, both options will have very limited to no direct impact on the health of soil itself in situ (Indicator ‘Impact on soil health’: PASS1 and 2 ‘0’). The options will instead ensure that, where possible, (uncontaminated) soil is reused and prevents the further and complete deterioration of that soil if not properly handled and re-used. Hence, PASS1 or a combination of both could play an important role in the transition to sustainable soil management by driving a greater re-use of uncontaminated soil where possible (Indicator ‘Transition to sustainable soil management and restoration’: PASS1 and 2 ‘+’).

A soil passport would enhance the management and reuse of excavated soil, ensure its quality and contribute to a more efficient use of (non-renewable) resources. A soil passport will reduce the risk of using contaminated soil elsewhere. Reusing excavated soils reduces transport distances to re-use sites as opposed to landfills, with a consequent impact on transportation costs and other environmental externalities. It also reduces costs associated with disposal, preserves landfill capacity, with a knock-on effect of reducing the costs and environmental pressures of developing new landfill capacity.

That said, there are factors which may somewhat limit the effect of the options, and hence why this option is anticipated to deliver a smaller benefit relative to options under other building blocks. First, the economic feasibility of re-using soil is limited by high transportation costs associated with moving soil over large distances, which makes it less economically feasible. Hence an increase in re-use would only occur where users of the soil can be found in close proximity to the excavation site – e.g. most likely in peri-urban areas. That said, although this inherently limits the quantity of soils which may benefit from being covered, it is true that the same land typically carries high agricultural and/or

[1004] Except when the soil is uncontaminated and excavated in the course of construction and if it is certain that the material will be used again on the excavation site development value, which would somewhat offset this limiting factor on the overall size of benefit achieved. Second, the re-use of soils would also depend on the development of a demand-side for excavated soil and a market of would-be buyers, which would not be present at the outset and may take time to develop. In addition, this may also require storage facilities to balance supply and demand over time (although it is noted that in Flanders there is a 3-year limit for how long excavated soils can be stored), which would require investment at additional cost. PASS2 would not necessarily bring in any additional delivery risks over and above those of PASS1 (Indicator 'Risks for implementation': PASS1 '--', PASS2 '0').

An important benefit delivered by the options would be a direct positive impact on harmonisation of collection and sharing of existing data on soil and ensure a level of common governance in soil management across the EU. Under PASS1, to facilitate the re-use of uncontaminated soil, there would be a mechanism in place to attain information on the status of the soil, and share this will the excavator and potential onward users. Under PASS2, the benefit would be higher as this mechanism takes the form of a digital passport harmonised EU-wide (Indicators 'Information, data and common governance on soil health and management' and 'Benefits': PASS1 '+'; PASS2 '++'). Furthermore, reusing excavated soil offers several additional direct economic benefits, such as: reduction in transportation distance to re-use sites as opposed to landfill, with a consequent impact on transportation costs, and other environmental externalities; reduction in costs associated with disposal; and preservation of landfill capacity.

Options under this building block would incur an additional administrative burden, as set out in the table below. Under PASS1, the EC would face a burden associated with developing guidance for the re-use of excavated soil. Member States would face a burden to design a policy or process to operationalise the obligation on them to ensure the proper treatment of excavated soils. The size of this additional burden would depend on 1) the current level of implementation by Member States relative to the objectives in the guidance document and 2) the extent to which Member States choose to implement the guidance document. Member States would likely face some costs in relation monitoring. Businesses would also incur a burden to engage in the information provision regarding the status of the soil as part of the transaction around the excavated soil. Under PASS2, the same information would likely already be collected under PASS1, and some the information needed for the soil passport such as the soil health descriptors may already be available under MON. However, there would be additional upfront burden for the EC to define the common digital passport and the creation of an IT infrastructure to manage and collate all the digital soil passports. For Member States, there will be an administrative burden related to setting up the process and structures to manage and issue applications for the passport, and to link these to the EU-system – based on experience with other EU-Member State linked IT systems, such a system could be costly to develop. There would also be an additional cost on businesses for logging information in the passports and attaining third party verification (Indicator 'Administrative burden': PASS1 '--'; PASS2 '---').

Table 8-1: PASS Option administrative burdens (EC = European Commission, MS = Member States) – further information on the method to calculating administrative burdens can be found in annex 9 section 6

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	Other - One-off	Other - Recurrent costs	TOTAL - one off	TOTAL ongoing

costs								
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
PASS1	34,000	-	91,000	1,400,000	-	-	120,000	1,400,000
PASS1+2	53,000	-	3,500,000	8,900,000	-	6,100,000	3,500,000	15,000,000

The stakeholders who would be most impacted by the introduction of a requirement on proper use of excavated soil would likely be those who are directly involved in the excavation and potential re-use of the soil, namely industries in the following fields: resource extraction and construction, land-fill operators, transport businesses, etc. Many of these actors will face some burden to consider the reuse of excavated soils. However, the benefits may very well outweigh this burden. For example, resource extraction and construction companies may save costs by not paying to landfill their soil (in a site that may be far away), but instead receiving money for transporting the soil to the location of reusage. PASS2 is not anticipated to materially impact the distribution of impacts (Indicator 'Distribution of costs and benefits': PASS1 '+'; PASS2 '0').

There are complementarities between the options under this and other building blocks: PASS 1 would build on SSM as the definition of 'proper treatment' is directly based on the list of criteria for sustainable management practices – indeed use of a passport could be deployed as one of the mandated SSM practices under that building block. PASS1 is also closely related to MON and DEF which could provide input information on the contamination and health status of soils for use in the sale of excavated land or digital passport – however there is uncertainty around whether information from these building blocks would provide information that is sufficiently granular for direct use, in particular in the case of MON. Furthermore, there is also a link to the LATA add-on, and any subsequent action around land take, given excavated soil is often the result of land-take activities (Indicator 'Coherence': PASS1 '+'). PASS2 is not anticipated to emphasise any synergies or contradictions with options under other building blocks.

8.3 Summary of stakeholder views

The importance of establishing proper treatment for excavated soils was highlighted by stakeholders during the Call for Evidence, where stakeholders were asked about their opinion on how to address excavated soils. Here, 17 out of 22 respondents expressed support for a common, EU-level approach for the conditions of treatment, storage and recovery of excavated soil as well as setting binding material recovery target for excavated soils. This was reiterated through the results of the OPC where there was a considerable support for obligation for Member States to create a soil passport for excavated soil, where many respondents either fully or somewhat agreed and only a handful of respondents either somewhat or totally disagreed.

Stakeholders highlighted the benefits associated with greater re-use of excavated soil, including the avoided disposal costs when excavated soil is brought to landfill.

During the stakeholder meeting, it was flagged that, in order to ensure that this option is effective, there is a need for common definitions (especially regarding waste) were required.

At the same time, some stakeholders (especially through the Call for Evidence) considered the soil passport to be a measure that can increase administrative burden for

Member States. It was also highlighted that the aims of the measure can be as effectively achieved by already existing legislation (e.g. by a revised Waste Framework Directive).

8.4 Findings

The direct impact on soil health from the soil passport is limited as it does not directly address soil health. The use of a passport may have a positive impact on the environment by reducing landfilling (positive effect on the climate through reduction of GHG emissions) and promoting recycling as well as reducing waste generation. Furthermore, establishing a passport for excavated soils will improve the information and data on soil health as well as positively affect sustainable soil management (through the reuse of soils instead of landfilling). The passport is expected to have a significant administrative burden for setting up the IT, potential transition costs and maintenance costs, and will bring additional costs for economic operators and construction companies. Because excavated soils fall under the scope of the Waste Framework Directive, there is a high risk of incoherence when the passport would be established by the Soil Health Law. Therefore, the add-on of the soil passport is not included in the preferred option at this stage.

Table 8-2: Overview of impacts

		PASS1	PASS1+2
Effectiveness	**Impact on soil health**	**0**	0
	Information, data and common governance on soil health and management	+	++
	Transition to sustainable soil management and restoration	+	+
Efficiency	**Overall benefits**	+	++
	Adjustment costs	+/-	+/-
	Administrative burden	--	---
	Distribution of costs and benefits	+	0
Coherence		+	0
Implementation risks		--	--

9 ANALYSIS OF OPTION UNDER NUTRIENTS TARGET (NUT)

9.1 Description of the options

Despite reducing nutrient losses resulting from several Directives, there are still significant impacts from nutrient losses occurring across Europe. It is estimated that 67% of Europe's ecosystem area is exposed to excessive nitrogen levels (78% of Nature 2000 areas, 65-75% of agricultural soils), mainly due to fertiliser use in agriculture. Increases in nitrogen in water poses direct threats to humans and aquatic ecosystems.[1005] The EU

[1005] Reactive nitrogen includes nitrate, ammonium and ammonia, gaseous nitrogen oxides, nitrous oxide and many other inorganic and organic nitrogen forms.

has set a target of 50% reduction of nutrient losses at EU level by 2030 as part of the Farm to Fork strategy.[1006]

Soil, and its management, have an important role in nutrient cycles and their loss to the environment: Nutrient losses can be a consequence of poorly managed soil, or the excessive or exclusive application nutrients. Soils used for intensive production exhibit much faster organic matter decomposition, and they are less able to store nutrients and carbon. Under this option the EU would set a legally-binding target of 50% reduction of nutrient losses at EU level by 2030 as part of the Soil Health Law, calling on Member States to define national or regional integrated nutrient management approaches to reduce nutrients losses including tackling hot spots.

9.2 Discussion of the relative impacts, costs and benefits of the options

Reducing nutrient loss will deliver a range of positive environmental benefits. ***Surface and groundwater quality*** will be improved, thereby lowering risks to human health and biodiversity (e.g. in the Jutland region in Denmark, water quality improved by 25% after starting an efficient control of manure and silage stores).[1007] Terrestrial biodiversity will also benefit from reduced nutrient losses as many habitat types and plant species are severely threatened by excessive nutrient input. Improved soil structure and nitrogen planning can reduce nitrous oxide (***climate change)*** by avoiding the conditions that cause nitrogen losses. The measures implemented to reduce nutrient losses may also have a range of complementary environmental benefits, such as improved soil fertility, and a reduction in acidification due to reduced fertiliser production and use. A reduction in nutrient loss will also reduce the amount of phosphorus extracted as a ***raw material*** (Indicator: Transition to sustainable soil management and restoration and Benefits: '++'). Defining the target in law will also provide a small improvement in the governance arrangements around soil health and management (Indicator: '+').

Improved drinking water quality by reducing nitrate concentrations in drinking water will have a positive impact on human health. Harmful algae growing in surface waters due to excessive nutrient availability can be toxic or harmful and negatively impact human health and recreation. Reducing nutrients in the ecosystem helps mitigate climate change and associated impacts on human well-being (e.g., heat waves, flooding). Human health is also improved by reducing nitrogen in the atmosphere, which can lead to respiratory illness and reduced visibility, especially in densely populated areas.

Measures to manage nutrients and nutrient loss in soils are likely to carry an upfront (and possible ongoing) cost associated with implementation (Indicator: Adjustment costs '--'). That said, these measures can also deliver economic benefits. By applying SSM practices to target and retain nutrients this can reduce input costs and ensure greater uptake of nutrients by the target crop. This is particularly pertinent given the recent sharp increase in fertiliser prices with the world experiencing a global mineral fertiliser crisis provoked by the high energy prices.[1008] If less artificial fertilizer is used, market volatility in fertilizer prices and the dependence of farmers and the EU on fertilizer could be reduced and domestic markets stabilised. In addition, reduced leaching of nutrients can lead to reduced risk to water filtration, which can reduce the burden on water suppliers and thus consumers. For phosphate reduction, a barrier to uptake of measures to reduce losses is

[1006] https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en
[1007] https://www.frontiersin.org/articles/10.3389/frsus.2021.658231/full
[1008] https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_6566

that in the current market, phosphate is less costly to buy new than manage better the circularity of inputs - hence fewer cost neutral management activities are available that can deliver reductions in nutrient loss. There will be overlap in the costs and benefits of achieving a nutrient target with those explored under the SSM (and somewhat the REST) building blocks, as many of the practices to reduce nutrient loss would be the same.

Implementing this option would also carry a moderate administrative burden (Indicator: '--'). Member States could face high one-off costs and moderate ongoing costs for developing a management plan, consulting with stakeholders and the EC on the nutrient load reductions needed to achieve these goals, as well as gaining support from external specialised consultants to assist with the development of the Action Plan. This could also involve the development of nutrient budgets where these are implemented to assist management (as in Denmark). Administrative burden estimates are presented in the table below.

Table 9-1: NUT Option administrative burdens (EC = European Commission, MS = Member States; no administrative burden for any other actors – e.g. businesses nor citizens – has been identified) – further information on the method to calculating administrative burdens can be found in section 6

	EC - One-off costs	EC - Recurrent costs	MS - One-off costs	MS - Recurrent costs	TOTAL - one off	TOTAL ongoing
	(EUR)	(EUR pa)	(EUR)	(EUR pa)	(EUR)	(EUR pa)
NUT	16,000	24,000	910,000	1,400,000	920,000	1,400,000

A key risk and potential barrier to the effectiveness of a nutrients target as part of the Soil Health Law is the interaction with actions around nutrients and nutrient loss under other legislation – both in terms of adding to the complexity of the policy landscape, but also regarding whether the Soil Health Law would be the most appropriate location for a legally binding target, which could then effectively influence the various drivers and sources of nutrient loss as a problem. As defined in the baseline section above, there are lots of links with existing Directives and legislation in terms of reducing nutrient losses. Some key examples of these include:

- Nitrates Directive – which requires Member States to apply agricultural action programme measures to promote best practice in the use and storage of fertiliser and manure;
- CAP – all Member States addressed the nutrient use efficiency in their CAP strategic plans. The Commission works with Member States to ensure that relevant interventions such as nutrient management plans, soil health improvement, precision farming, organic farming and agro-ecology, higher use of leguminous crops in crop rotation schemes, etc. are widely adopted by farmers.
- Water Framework Directive- which aims to ensure that quality of water is protected through (amongst other measures): monitoring of core parameters (including N), protection of nutrient-sensitive areas and ensuring rivers, lakes and transitional waters have the correct nutrient conditions.

From the legislation above, it is clear that there are multiple policies and measures aimed at taking action around nutrient losses. Each are focused on one or more nutrients of reactive nitrogen forms derived from fertilisers. Hence introducing a legal target as part of the Soil Health Law risks incoherence with other Regulations.

Furthermore, as noted soil has an important role to play in the nutrient cycle. Soil has nutrients applied to it in agriculture, and how soil is managed can have an influence on the quantity of nutrients lost. However, not all sources and drivers of the problems associated with nutrient loss interact directly with soil – e.g. non-agricultural property development and the management of P in wastewater is a key part of the nutrient story. Also, nutrient loss is not strictly a problem of soil health – as defined in the soil health descriptors, soil health depends on achieving and maintaining nutrient content in a given range, rather than limiting loss strictly. Nutrient losses can also occur from healthy soil, particularly if the management practice increases nitrogen for example legume cover crops. Hence it is questionable as to whether a nutrient loss target as part of a Soil Health Law would be the most applicable place to be able to effectively tackle all drivers and sources of the problems associated with nutrient loss. Elaborating further, management of soils can form part of the measures to meet the requirements of the wide ranging legislation, however it should be seen as a facilitator alongside technological advancements, reductions in use, improvements in plant and animal science and improvements in practice. Many of these enhancements may involve sustainable soil management practices but many are not relevant to the soil ecosystem. Therefore setting targets within the Soil Health Law may result in an ineffective management of all sources and could limit the implementation of all relevant actions (Indicator: Risks to implementation: '---'). Furthermore, a nutrients target would only deliver limited additional benefits for soil health (Indicator: '+').

Monitoring of soils to support nutrient management planning is critical in ensuring balance and effective nutrient applications – hence there is a key and complementary link to the MON building block. This, together with the coherence risks above suggests a mixed overall picture in terms of synergies with the broader SHL package and legislative landscape (Indicator: coherence '+/-')

It is uncertain where the adjustment costs will fall as this will depend on the method of implementation by the Member State – in the first instance, the obligation to achieve the nutrient loss target is placed on Member States. That said, land mangers/farmers will be impacted by these measures as they will need to implement sustainable soil management practices to reduce nutrients losses, and will not accrue all the benefits (as some are societal) of the changes made. Furthermore, measures are likely to predominantly impact rural areas as agricultural and forestry land represents a greater land area where nutrients are applied in greater amounts – hence the costs (and benefits) of implementing these measures will also fall more so on rural areas. (Indicator: Distribution of costs and benefits '-').

9.3 Summary of stakeholder views

Through the engagement activities, stakeholders did recognise the value in a nutrient loss target. According to the OPC questionnaire, which asked the question, 'How would you rank the effectiveness of the following measures in achieving the 50% reduction of nutrient losses by 2030', most survey responses (across all measures an average of 77%) found that either 'legally binding targets at EU level' and 'legally binding targets at national/regional level' would be either reasonable or very effective for achieving the

50% reduction of nutrient losses in 2030. It is notable that the response across the measures mentioned[1009] in the survey was positive. However, it is important to note that the survey question did not distinguish between whether such a target should be implemented explicitly as part of a Soil Health Law or otherwise. Furthermore, in other engagement activity, some stakeholders questioned whether a legally mandated target is achievable.

9.4 Findings

In summary, setting a legally-binding nutrients target would ensure the delivery of a wide range of environmental benefits and would have a positive influence on the transition to SSM and restoration more broadly, and many of the measures taken under other building blocks have close synergies with, and would work towards, achieving a nutrients target: By applying SSM practices to target and retain nutrients this can reduce input costs and ensure greater uptake of nutrients by the target crop (this is particularly pertinent given the recent sharp increase in fertiliser prices). In addition, reduced leaching of nutrients can lead to reduced risk to water filtration, which can reduce the burden on water suppliers and thus consumers.

However, there are challenges to a nutrients target being an effective part of the SHL package. First, there are multiple policies and measures aimed at taking action around nutrient losses, each are focused on one or more nutrients of reactive nitrogen forms derived from fertilisers. Second, not all sources and drivers of the problems associated with nutrient loss interact directly with soil, and nutrient loss is not strictly a soil health problem. Hence having a legal nutrient reduction target as part of the SHL may not facilitate an effective consideration and control of all components and drivers of nutrient loss.

Table 9-2: Overview of impacts

		NUT
Effectiveness	**Impact on soil health**	+
	Information, data and common governance on soil health and management	+
	Transition to sustainable soil management and restoration	++
Efficiency	**Benefits**	++
	Adjustment costs	--
	Administrative burden	--
	Distribution of costs and benefits	-
Coherence		+/-
Implementation risks		---

[1009] Measures included; advisory services for farmers, recommendations to MS on nutrient management, action plan at EU level, national/regional actions plans, legally binding fertilization rates for the main crops, adapted to regional pedo-climatic conditions, legally binding targets at EU level, legally binding targets at national/regional level and continue funding research and innovation actions to address safe and environmentally sound solutions.

ANNEX 11: PREFERRED OPTION

1 WHAT IS THE PREFERRED OPTION?

1.1 Summary

A preferred option under each building block has been selected based on the evidence gathered around the impacts, risks, stakeholder opinion and the links and consistency between options selected across the building blocks. The preferred package of options for the Soil Health Law is presented in the table below. A preferred option is shown for each of the core five building blocks. In addition, the table also highlighted where the analysis of the 'add-on' options could be complementary to those options selected under the 5 building blocks. Note where options have not been selected under a building block (i.e. for the add-ons CERT and PASS), this implies only that it is not proposed to take an option forward as part of the Soil Health Law package at this point. As described in the analysis of these options, there are many benefits to their implementation and as such these may be considered separately in another legislative initiative.

The preferred option is the combination of the options 3 of all building blocks, except for a small adaptation to Option 3 for REST/REM and SSM. Specifically Option 3 under the REST/REM building block is adopted with the exception that in case of unacceptable risks for CS, Member States are obliged to manage and reduce the risks, but not necessarily through remediation of the contamination only. I.e. Member States should implement risk-based actions that ensure contaminated sites no longer pose an unacceptable risk (also called risk reduction or risk management measures) which may include remediation (= reducing or removing soil contamination) but also isolation or containment of the contamination, use restrictions or safety measures, that break the source-pathway-receptor chain, but do not necessarily remove or reduce the contaminant load. This package of options balances between the need to reach the objective of healthy soil by 2050 in an effective manner and avoiding unnecessary regulation at EU level as well as administrative burden. The preferred option also integrates the add-on on land take.

Table 1-1: Summary of the preferred option(s)

	Building block					***Add-ons***			
Building block	SHSD	MON	SSM	DEF	REST/REM	*LATA*	*CERT*	*PASS*	*NUT*
Preferred option *(with add-ons retained)*	3	3	3(+ 4)	3	3(/2)	*1+2*	*N/S**	*N/S**	*1*

*Note: * = no option selected*

1.2 Linkages between the building blocks

The preferred package of options across the different building blocks has also been selected taking into account the coherence and synergies of the options across the building blocks. In particular:

- The selection of Options 3 under both SHSD and MON is synergistic as it is effective that for those thresholds developed EU-wide, the EU should also define the sampling methodology, and likewise for those developed at Member State level. This is complementary as the detailed consideration around the way in which the thresholds should be defined (in particular those defined at Member State level taking into account location-specifics) will also be informative for defining suitable sampling strategies and approaches to measuring against these descriptors and thresholds.

- The selection of Options 3 under SHSD, MON and also SSM and REST is also consistent. The implementation of options under SHSD and MON form a necessary basis for ambition to achieve good health status in soils and restoration under SSM and REST. Under Options 3 under SSM and REST, the programms of measures with measures for restoration and list of mandated SSM practices is not completely prescribed across the EU and Member States have some flexibility to adopt programmes for SSM and restoration in each soil district which reflect the location-specific considerations. Actions taken under SSM and REST will also contribute to the achievement of a nutrients target (NUT).
- The identification of contaminated sites and those with an unacceptable risk under DEF is a necessary basis for ambition to reduce and keep the risk of contaminated sites to acceptable levels by 2050 at the latest under REM.
- LATA would be complementary to, and/or could sit within SHSD and MON respectively. These sit consistently with Options 3 under SHSD and MON as the definition of land-take would become one of the descriptors which is defined at EU-level, and the monitoring of land-take could be incorporated in the wider monitoring programme instigated under MON.

2 COSTS AND BENEFITS OF THE PREFERRED OPTION

2.1 Benefits

2.1.1 Environmental benefits

Soils in the EU are unhealthy and continue to degrade. This continued degradation places at risk the multitude of critical ecosystems services (e.g. food, biomass and fibres, raw materials, regulation of water, carbon and nutrient cycles and biological diversity) that soil - and the organisms that it hosts - provide. Information, data and common governance on soil health and management is lacking or incomplete and the transition to sustainable soil management and restoration is needed but not yet uniformly happening. These problems are driven by multiple drivers, including market and regulatory failures, and behavioural biases. The SHL preferred option package contains a range of measures across the building blocks which aim to tackle the multiple drivers of the continued degradation of soils.

Soil is essential for all terrestrial ecosystems and their biodiversity, and the ecosystem services they provide. Hence by delivering good soil health, the SHL package will deliver substantial ***environmental benefits***. Good soil health, achieved through the implementation of SSM and restoration practices will:

- ***Support climate change mitigation***, through for example: Increased sequestration of carbon as SSM and restoration practices increase levels of soil organic carbon, reduced N being released as N_2O to the atmosphere increasing the greenhouse effect, reduced use of energy due to less machinery use (e.g., with reduced tillage).
- ***Improve quality of natural resources*** - soil, but also: ***Air*** through greater protection of soils against erosion which will reduce the contribution of soils to

windblown dust, and improved nutrient management will reduce the contribution of soils to concentrations of ammonia in the air; and ***Water*** by reducing the risk of N leaching into waterways causing eutrophication, and improving water quality, and reducing standing surface water and infiltrate and store more water resulting in reduced flood and drought risks.

- ***Improve biodiversity***: Soil biodiversity is an indicator for soil health, as it supports the correct functioning of soil processes. Hence there is a positive relationship between soil biodiversity and control of greenhouse gases, retention of soil nutrients and biotic resistance to pests.

Likewise the remediation of contaminated sites will also deliver a range of environmental benefits: it will improve the quality of natural resources by reducing the presence of toxic chemicals in soils and water; it will have a positive impact on climate change mitigation in the medium to longer term (e.g. there is evidence that pollution reduces the capacity of soil to absorb carbon dioxide); and it will reduce the negative impacts from toxic chemicals on the wider environment, from impacts on individual species and populations to impacts on overall biodiversity.

2.1.2 Economic benefits

The SHL package will also deliver several significant ***economic benefits.*** Indeed, investment in soil for any one outcome can deliver multiple benefits. These benefits can include maintaining or increasing yields and revenues for agricultural and forest land-owners, reduction in input costs, but also enhancing reputation and opening up financing opportunities.[1010] For many SSM practices and/or actions to achieve a nutrients target, there will be an economic benefit, in particular to agricultural or forest land-owners through increase in productive output or yield of the soil, or reduction in inputs to production. For example, the sample of illustrative practices quantitatively assessed show these economic benefits could be substantial based on a simple extrapolation to EU-level: cover crops €9.5bn pa, reduced tillage €6bn to 12bn pa, crop rotation €0.6bn pa (for barley only), use of organic manures €1.45bn to €2.7bn pa, reduced stocking density €0.6bn to 2.7 bn pa. Although in many cases such benefits take time to be realised, in the longer term the benefits can be in the same order of magnitude if not higher than the costs. These economic benefits accrue even before the environmental and social benefits of such measures are considered.

The remediation of sites will also deliver economic benefits. Pollution of soils with heavy metals can reduce the growth of plants, performance and yield.[1011] Significant social and economic benefits would be expected due to avoided health impacts, regeneration of land value, and provision of ecosystem services. Studies estimate the health impacts from exposure to harmful contaminants to costs billions of euros per year due to individual chemicals/ groups of chemicals, e.g. the disease burden from endometriosis alone caused by phthalates has been estimated to be over €1 billion annually in the EU;[1012] costs from PBDEs across the EU due to IQ losses and intellectual disability have been estimated to be €10 billion annually across the EU;[1013] EU health

[1010] https://www.wbcsd.org/contentwbc/download/6149/85658/1
[1011] https://www.sciencedirect.com/science/article/pii/S1002016017603060
[1012] Milieu (2017) The Study for the strategy for a non-toxic environment of the 7th Environment Action Programme Final Report, EC, DG Environment
[1013] Trasande, et al. (2016). Burden of disease and costs of exposure to endocrine disrupting chemicals in the European Union: an updated analysis. Andrology, 4(4), 565–572.

burden from lead and methylmercury is estimated to be €47 billion annually.[1014] No estimates for the total monetary value of health impacts from soil contamination are available in the literature and attributing chemical exposure (e.g. human biomonitoring data) and impacts (e.g. health costs) to contaminated sites is challenging, as humans are continually exposed to chemicals from a multitude of different sources. However, given the extent of contamination across Europe (166,000 sites needing remediation) and the range of contaminants present on CSs in Europe (e.g. chlorinated hydrocarbons, (polycyclic) aromatic hydrocarbons, heavy metals, phenole, cyanide, polychlorinated biphenols, and pesticides),[1015] the overall health impacts, and consequent economic impacts, are anticipated to be of large magnitude.

With respect to land value, it is estimated that remediation of 166,000 sites across Europe could lead to an ongoing benefit of €12 - €59 million per annum if used for agricultural purposes, or more where the land is used for higher value activities (e.g. housing, commercial property, etc). Remediating contaminated land would reduce the impacts and costs of corresponding additional land take. With ecosystem services ranging from €20 euros and €5,000 euros per hectare, the cumulative benefits would likely reach several hundreds of millions of euros per year by the end of the time horizon. The regeneration of land value is a critical benefit given that the EU currently faces significant pressure regarding land use.

The preferred option will also create opportunities for SMEs both for growth (e.g. soil testing labs, investigation and remediation of contaminated sites, advisory services for soil health) and for innovation (e.g. “artificial intelligence solutions from sensing systems” and “field-based measuring systems - hand-held spectrometers, portable DNA extraction, on-site chemical analysis”). Improvement in monitoring is expected to lead to technological development and innovation more generally, and stimulate academic and industrial research. Furthermore, increasing the amount of publicly available soil monitoring data will help to increase the public awareness of soils and the challenges they face.

2.1.3 Social benefits

Investment in additional activities to achieve good soil health and zero pollution will also deliver strong ***social benefits***, in particular significant positive employment affects. It is estimated that the SHL package could directly increase jobs by around 35,000 FTEs on an ongoing basis over the first ~20 years. In addition, the sample of 5 illustrative SSM practices, could deliver a further 300,000 to 420,000 extra annual working units (AWUs)[1016] per annum could be created associated with implementation of three SSM practices EU-wide on an ongoing basis[1017]. Furthermore, there will be additional employment benefits as the initial investment ripples through the EU-economy. Including indirect and induced effects, it is estimated that the total employment effects of the SHL package could be around 36,400 additional FTEs on an ongoing basis, plus up

[1014] Amec Foster Wheeler et al. (2017) Study on the cumulative health and environmental benefits of chemical legislation. European Commission DG Environment.

[10151015] Occurrence is reported in data available through the JRC ESDAC - [Soil Contamination - ESDAC - European Commission (europa.eu)]

[1016] Annual work unit (AWU) is the full-time equivalent employment, i.e. the total hours worked divided by the average annual hours worked in full-time jobs in the country. One annual work unit corresponds to the work performed by one person who is occupied on an agricultural holding on a full-time basis.

[1017] Employment effects for only 3 of the 5 measures in the illustrative sample were made. The nature of the costs for two measures (reduced tillage and crop rotation) suggests that the allocation to ‘labour’ of these costs is negligible, and in fact these measures may have a small negative impact on labour demand.

to a further 560,000 agriculture AWUs associated with implementing the three, illustrative SSM practices. It is important to note that estimating direct and total jobs associated with the SHL package carries many uncertainties and there is greater confidence in the estimation of direct, relative to the indirect and induced effects included in the 'total' estimated effects. However it is clear that: (a) Some of the activities carry a potentially significant employment benefit, including CS investigation and remediation; (b) but the largest employment benefit is likely to come through the implementation of restoration and SSM practices, many of which will require significant labour input to the ongoing management of agricultural, forest and urban soils; and (c) alongside the direct effects, there may be important and significant indirect (and induced) employment effects which provide an additional benefit to implementing the SHL package.

Healthy soils are critical for supporting human health.[1018] They are essential for food, biomass and fibre production, the production of certain medicines, and retaining and filtering water. Hence soils play a critical role in food production and security, and through achieving good soil health, the SHL package will improve food production and hence security for the EU. Poor soil health also poses risks to human health — both indirectly through its contribution to air and water pollution (as described above under environmental benefits), but also through the consumption of contaminated food and drinking water, and directly through exposure to contaminated soil. By reducing the risks associated with contaminated sites, the soil health package will deliver important benefits for the health of EU citizens.

The SHL package contains several options which will lead to a substantial ***improvement in the information, data and reporting around soil health***. The SHL package will facilitate the collection of robust, consistent, comparable and comprehensive data, in particular through: its definition of soil health descriptors, ranges and districts where soil health is measured, the obligation for Member States to reliably monitor soil health and the effectiveness of the measures taken,; and the identification and investigation of potentially contaminated sites. These options are critical to the delivery of effective and efficient restoration and remediation activities under other building blocks to deliver good health status and the overarching objectives of the SHL package. The achievement of healthy soils cannot happen without a regular and adequate assessment of soil health and monitoring of its changing status with time, together with the monitoring of the effectiveness of the measures taken. Furthermore, the identification of (potentially) contaminated sites and appropriate assessment of the risks of sites are a prerequisite for effective and efficient remediation. The need for additional monitoring is emphasised as a key message in the EEA's Zero Pollution Monitoring Assessment 2022,[1019] where they note that: *Less is known about soil pollution and its associated impacts on ecosystems than about other issues, such as air pollution. There is a need for ongoing, targeted monitoring to better inform decision-making and to assess progress towards meeting the long-term zero pollution objectives.*

The SHL package contains several options which will critically ***improve the governance of soil health*** by defining in law several key concepts and definitions, and placing obligations directly on key stakeholders to facilitate the delivery of good soil health. In particular:

[1018] https://www.eea.europa.eu/publications/zero-pollution/health/soil-pollution
[1019] https://www.eea.europa.eu/publications/zero-pollution/ecosystems/soil-pollution

- Through SSM, the SHL will provide a definition of sustainable soil management and require Member States to apply the principle of non-deterioration and ensure that all soils are used in a sustainable manner.
  To achieve this transition in practice throughout the entire territory of the EU, the EU Soil Law will establish the principles of sustainable soil management across all relevant soil threats for agricultural, forestry and urban soils (some of which will be mandatory for Member States to adopt) closely following existing guidelines and scientific recommendations.
- Through REST/REM, the SHL will implement a legally binding target that by 2050 all EU soil ecosystems should be in healthy condition.
  For soil contamination, the SHL will apply the zero pollution ambition and adopt a legally binding target that by 2050 soil contamination should be reduced to levels no longer expected to pose risks for human health and the environment. Similar to other environmental legislation, Member States should adopt programmes of measures for every soil district and revise these plans periodically – these will be guided by certain common minimum criteria developed by the EC.[1020] The identification of contaminated sites require Member States to implement a systematic approach to reduce and keep the risk of contaminated sites to acceptable levels, e.g. through risk reduction or soil remediation activities. Prioritisation and planning of the remediation measures for contaminated sites would be left entirely to the Member States in this scenario.

2.1.4 Quantification of benefits (partial)

Best estimates of the ***total environmental and economic benefit*** of achieving good soil health (and hence reversing existing soil degradation) suggest that these are significant, and that the trade-off between benefits and costs would be net beneficial.

The benefit can be quantified considering the costs of non-action in addressing soil degradations. If the soil degradations are resolved, the cost of degradation becomes zero and this reduction in costs represents the benefit of taking action to resolve soil degradation, that is to manage soil sustainably and restoring unhealthy soils. The cost of non-action has been quantified in Annex 9 section 4.2.2.

However, not all this benefit can be attributed to the proposed Soil Health Law alone, since other new EU initiatives can be expected to partially contribute to soil health. The estimation of the residual benefit of the Soil health Law is done in the main chapter 5.1.1. Noting the uncertainty on the estimation, the estimated benefits are of the order of EUR 50 billion (excluding contamination) – while for soil contamination the prudent amount of EUR 24.4 billion is taken, e.g. the intermediate estimation between the lower and upper quantified value for soil contamination (which differ by two orders of magnitude).

[1020] It could be required e.g. to present in the plans the results of the monitoring and assessment of soil health in the different soil districts, to select restoration measures on the basis of an indicative annex, to report on legislative actions taken at national level or to inform or consult the public on the content of the programms of measures.

A report by the ELD initiative[1021] adopted two approaches to valuing the ecosystem service losses from land degradation. One approach estimated the range of lost value to be between EUR 287bn pa to 334bn pa, whereas the second placed the value of losses to be much greater at EUR 929bn to 1,079bn pa. The precise methods used and impacts captured are not completely clear, as such for the cost-benefit analysis of this study preference is given to the bottom up estimate of impacts of soil degradation based on a revision to the estimates from the 2006 IA, even though these are partial. That said, the ELD Initiative estimates are useful to demonstrate that the benefits of improving soils to good health are likely to be substantial, and could be significantly larger than the 'conservative' partial estimates used in the present cost-benefit analysis.

2.2 Costs

Implementing the SHL Package will incur a number of costs. First, estimates for an enhanced monitoring network suggests an additional cost of around EUR 42m pa (2020 prices or 46m in 2023 prices relative to a baseline cost for the LUCAS survey programme of around EUR 3.5m pa).[1022]

The total costs for all actors to identify and investigate contaminated sites (costs likely to be split between public and private actors) are highly uncertain and could reach a total of €29.1 billion (2023 prices). If spread over 15 years, this could cost €1.9 billion per year (2023 prices), which may be ten-fold higher than under the baseline. That said, several Member States would likely face minimal additional costs in the context of investigation, as substantive progress has already been made, however, others would be required to increase efforts substantially. Any increase in economic costs of investigation would depend on the time horizon set for Member States to identify all PCSs and CSs. These options are critical to the delivery of effective and efficient SSM, restoration and remediation activities under other building blocks that form part of the overall package.

The implementation of SSM, restoration and remediation actions will all incur a significant adjustment cost, both upfront and ongoing. Estimating the costs of these actions robustly is challenging given the nature and gaps in the underlying evidence base. The overall costs of SSM and restoration practices will ultimately be driven by which practices are adopted, which in turn will depend on a range of variables (including the way in which good soil health and districts are defined under SHSD, and the monitoring methods set under MON – both will have a strong influence on the number of districts identified as being unhealthy and the reasons for this, and hence will have a strong influence on what and how many restoration actions are required). Analysis has been undertaken to produce an illustrative, order-of-magnitude estimate for a selected sample of practices. This analysis shows that the costs of implementing such measures EU-wide would be significant and run into the €10's billions (combined total cost of the 5 illustrative measures ranged from EUR 26bn to 35bn pa in 2020 prices or EUR 28bn to 38bn pa in 2023 prices).

The 2006 IA also produced a quantitative assessment of costs based on different illustrative scenarios (but also caveated that these were *highly speculative nature* and *under no circumstances to be looked at as the real implementation costs of the Soil*

1021 https://www.eld-initiative.org/fileadmin/ELD_Filter_Tool/Publication_The_Value_of_Land__Reviewed_/ELD-main-report_en_10_web_72dpi.pdf

1022 Baseline costs would also capture costs for existing national monitoring networks, for which cost data is not available

Framework Directive). In total, the combined cost per annum across the 4 agriculture threats (erosion, soil organic matter loss, compaction and salinisation), and forestry and construction practices, the total costs came to EUR 14.4bn pa (2003 prices) – or EUR 20.3bn 2023 prices. Although both the estimation under this IA and under the 2006 IA are strongly caveated, in particular as it is not possible to define the impacts of measures directly on soil health indicators (and hence select a specific set of measures to achieve good soil health), there is some corroboration between the two estimates which provide an illustration of the potential order of magnitude of effects.

For the remediation of contaminated sites, as for investigating these sites, there is a wide uncertainty range around the estimation of costs. Assuming a time horizon of 25 years, the intervention could require an average remediation rate of 6,600 sites per year. This represents approximately twice the costs of the baseline (e.g. €1,000 million per year rather than €500 million per year, if an average remediation cost of €150,000 per site is assumed, all 2023 prices).

Alongside monitoring costs, the SHL package will imply an additional administrative burden of around EUR 2.9m upfront cost (annualised figure over 20 years) and around EUR 7.0m pa on an ongoing basis (2020 prices, or EUR 3.2m upfront annualised and EUR 7.7m pa in 2023 prices).

2.2.1 Profile of quantified costs and benefits and benefit-cost ratio

2.2.1.1 Methodology for quantifying costs and benefits

Where possible, this IA has sought to assess the impacts of the SHL quantitatively, as guided by the Better Regulation Toolbox. However, critical limitations in the underlying evidence base and assessment approaches have meant that not all effects have been quantified and/or monetised. In particular, it is unknown at this stage what exact SSM and restoration measures, and measure to reduce nutrient losses will be implemented, where and to what extent. Furthermore, evidence around the costs of different SSM measures and how these vary in different contexts is limited and dispersed, and evidence to link the implementation of individual or groups of measures to a defined change in a specific or multiple soil health indicators is also unavailable. In addition, techniques to quantify and monetise all the benefits of implementing such measures are not available. These limitations have been presented clearly throughout the analysis such that they can be considered when drawing conclusions from the results.

Where effects have been quantified and monetised, a variety of techniques and approaches have been deployed to do so:

- Administrative burdens have been assessed following the steps of the Standard Cost Model (or SCM)
- The costs of an expanded soil health monitoring network have been appraised through detailed analysis of different types of monitoring costs and an estimate of the number of sites required to monitor soil health across the EU to a 5% error margin made by the JRC.
- Given the limitations noted above around defining a cost of SSM measures, two approaches have been adopted: (a) implementation costs have been estimated for an illustrative sample of 5 measures, selected to work across multiple soil health

threats, simply extrapolated to EU-level; (b) reflected on and referenced to similar work undertaken as part of the 2006 Impact Assessment which defined a scenario established packages of concrete measures to address various soil health threats.

- Job and employment effects were estimated using an Input-Output methodology for the sample of 5 illustrative measures.
- The costs of identification and remediation of contaminated sites were estimated through a detailed review of the costs of conducting different stages of site identification and risk assessment, and associated with various remediation techniques. These were combined with estimates of the numbers of CS made by the EEA.
- The costs of soil degradation were estimated, on the basis of the work undertaken in the 2006 IA and in parallel by Montanarella (2007) – by implementing measures to restore soils to good health, these costs are avoided and hence represent the benefits of implementing the SHL. A detailed review of more recent estimations of costs of specific soil degradations was made in order to review, revise and update elements of the estimation for specific soil health threats.

2.2.1.2 Preferred option

Only a sub-set of the impacts (in particular benefits) of the SHL have been quantified and monetised. Furthermore, as noted in preceding sections, there is uncertainty around many of the quantitative estimates. These limitations aside, it is informative to consider the potential temporal profile of these impacts and how they may come together to present an overall net-present value or benefit-cost ratio for the SHL once discounting has been applied. The following table presents a summary of the quantified impacts, what the point estimates represent that have been presented to this point, and some assumptions around the temporal profile of these impacts.

Table 2-1: Temporal nature of quantified effects

Quantified effect	Effect estimate (2023 prices)	Explanation of point estimate	Assumptions around temporal nature of effect
Quantified effect	**Effect estimate (2023 prices)**	**Explanation of point estimate**	**Assumptions around temporal nature of effect**
Benefit – avoided costs of soil degradation (Excl. contamination)	EUR 50bn pa	- Estimate of the annual costs caused by soil degradation. - Represents the benefits that can be captured should all soils achieve good health. - Hence this represents the value that can be captured in 2050.	- SHL achieves EUR 50bn pa benefits by 2050, and each year after - Benefits will start to accrue when Member States begin to implement SSM and restoration measures. - For simplicity, assume linear increasing trend from start date to 2050
Benefit – avoided costs of soil degradation (contamination)	EUR 24.4bn pa	- Estimate of the annual costs caused by soil degradation. - Represents the benefits that can be captured should all CS be remediated. - Hence this represents the value that can be captured in 2050.	- SHL achieves EUR 24.4 bn pa benefits by 2050, and each year after - Benefits will start to accrue when Member States begin to remediate CS. - For simplicity, assume linear increasing trend from start date to 2050
Costs of enlarged	EUR 46m pa	- Estimate of annual cost of	- Annual cost spreads total monitoring cost

Quantified effect	Effect estimate (2023 prices)	Explanation of point estimate	Assumptions around temporal nature of effect
Quantified effect	**Effect estimate (2023 prices)**	**Explanation of point estimate**	**Assumptions around temporal nature of effect**
monitoring network		enlarged network	over each 5 year campaign. Hence assume flat cost pa.
Costs to identify CS	Could reach total EUR 29 bn (or EUR 1.9bn pa spread over 15 years)	- This represents the total, cumulative cost of identifying all CS.	- Member States have to set up the register of CS - Assume flat, constant trend over investigation period. Assume full investigation period lasts 15 years. - Once all sites have been identified, assume no ongoing cost.
Cost of remediating CS	EUR 24.9bn (or EUR 1,000m pa where spread over 25 years)	- This represents the total, cumulative cost of remediating all CS.	- Costs will start to accrue when Member States begin to remediate CS. - For simplicity, assume flat, constant trend in costs from start date to 2050
Cost of implementing SSM	EUR 28bn to 38bn pa based on illustrative sample of 5 measures (2006 IA estimate based on 4 agriculture threats + forestry and construction measures totalled EUR 20.3bn)	- Illustrative estimates of total, annual costs of SSM and restoration measures to improve soils to good health - Costs are ongoing once deployed, not one-off - Represents the costs that can be captured should all soils achieve good health. Hence this represents the costs in 2050 and each year thereafter.	- Costs will start to accrue when Member States begin to implement SSM and restoration measures. - For simplicity, assume linear increasing trend from start date to 2050, and constant thereafter
Additional administrative burden - upfront	EUR 48m	- Total upfront costs to EC and Member States to implement different elements of the SHL package.	- Costs will likely begin to impact significantly at transposition. - Costs will then be spread over an implementation period of a number of years as Member States set up functions and systems to implement different elements of the SHL. This period is somewhat uncertain, but assume this lasts 5 years. Costs in practice may vary over this period, but assume flat, constant profile for simplicity with equal costs in each of the 5 years.
Additional administrative burden - ongoing	EUR 8.0m pa	- Total ongoing costs to EC, Member States and businesses to implement different elements of the SHL package.	- Costs will likely begin to impact significantly at transposition. - Costs will then occur each year on an ongoing basis. Costs may vary in practice year on year, but assume flat, constant profile for simplicity

The selection of an appropriate appraisal period over which to depict these impacts is challenging, as many of the impacts take a different profile, and many of the impacts will continue on an ongoing basis after the obligations have been met in 2050. An appraisal period to 2060 has been selected to allow the capture of some of the ongoing benefits (and costs) of soils in good soil health (relative to the baseline) after 2050. All impacts are discounted to 2020, using a discount rate of 3% (as recommended in the Better Regulation Toolbox).

Based on the assumptions set out in Table 2-1 above, the figure below depicts the temporal trend of impacts over the appraisal period in 5-year steps (aside from the initial years of implementation). The cumulative, discounted present value of each effect and net-present value and benefit-cost ratio of the SHL package is then presented in Table 2-2 below.

Figure 2-1: Temporal profile of impacts

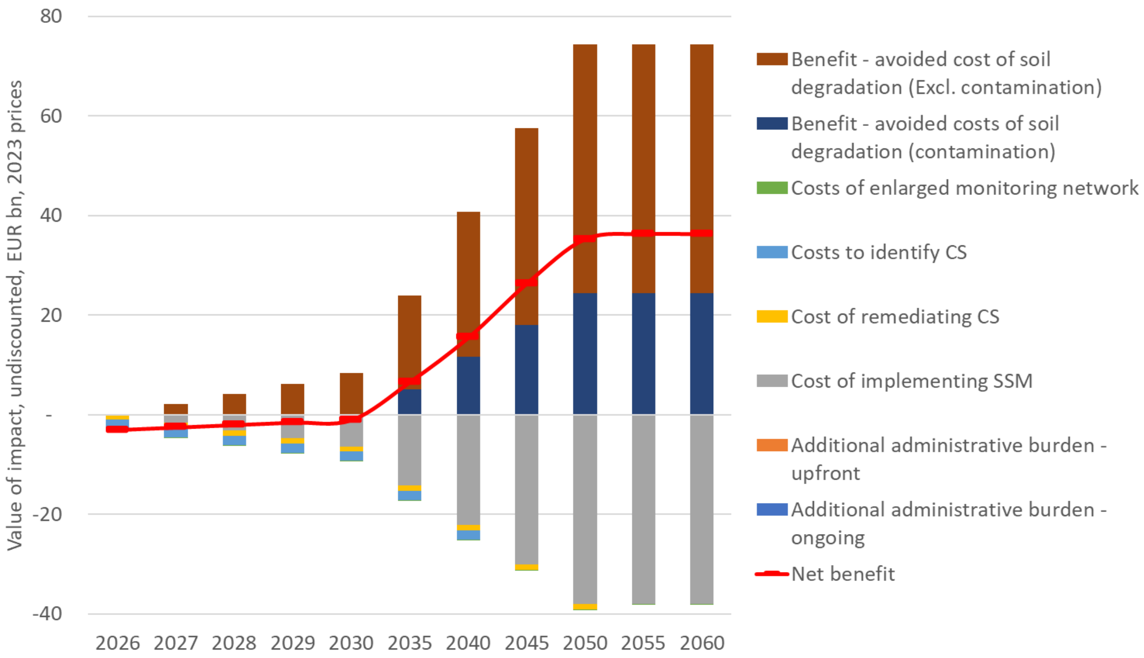

Table 2-2: Present value of impacts, and summary economic metrics

Quantified effect	Discounted present value (EUR m, 2023 prices, discounted to 2020, cumulative over appraisal period to 2060)
Benefit – avoided costs of soil degradation (Excl. contamination)	550,000
Benefit – avoided costs of soil degradation (contamination)	230,000
Costs of enlarged monitoring network	-940
Costs to identify CS	-22,000
Cost of remediating CS	-16,000
Cost of implementing SSM*	-420,000
Additional administrative burden - upfront	-41
Additional administrative burden - ongoing	-160
NET PRESENT VALUE	**320,000**
BENEFIT-COST RATIO	*1.7*

Notes: *Adopts high end of the range of EUR 35bn pa

There are large uncertainties around the estimation of effects, and limitations to the approach. Those factors aside, the quantified impacts suggest that the SHL package is likely to deliver a significant net benefit – estimated to be around EUR 320bn (2023 prices, discounted to 2023) over the appraisal period to 2060. This net benefit would be even greater where the appraisal period extended to capture further the ongoing benefits of avoided costs of soil degradation. Furthermore, this estimate uses the upper bound for the costs of SSM measures of EUR 38bn pa once fully implemented (taken from the illustrative sample of 5 measures) – where the lower cost of EUR 20.3bn pa is used (taken from the 2006 IA), the net discounted present value increases to EUR 510bn. This also only captures a partial estimate of the benefits of avoided costs of soil degradation, as explored in the benefits section above.

The benefit-cost ratio of the SHL package over the appraisal period is around 1.7. This is slightly lower than other benefit-cost ratios taken from the literature, in particular:

- The cost of inaction on soil degradation, which outweighs the cost of action by a factor of 6 in Europe;[1023] and
- every €1 investment in land restoration brings an economic return of €8 to €38.[1024]
- A report by the ELD initiative[1025] concluded that investing in sustainable land management is consistently shown to be economically rewarding with benefits outweighing costs severalfold in most cases.

That said, different studies have adopted different approaches to estimating both benefits and costs. Furthermore, this BCR is more tailored to the specific SHL package and is a lower bound estimate - this would be higher at 3.0 where a lower bound cost of SSM measures is applied, and would again be higher where the appraisal period is extended and/or should the many benefits not quantified be included in the monetised estimates. In addition, this aligns well with the BCR of measures assessed as part of the 2006 IA, the aggregate BCR of which was 1.3. What is consistent across the studies is that the BCR of actions to restore and remediate soils in the EU is positive – underlining that the SHL and the restoration of soils to good health will likely deliver a net benefit.

2.2.1.3 Sensitivity Analysis

This section calculates how much the Net Present Value (NPV) and the Benefit to Cost Ratio (BCR) variates when costs and benefits change compared to the central computation. This provides an indication of how the uncertainty in the costs and benefits impacts the estimation of NPV and BCR.

Key variables being considered.

The variables representing the largest share of the potential benefits and costs of the Soil Health Law, and hence considered as key in determining the discounted costs, benefits,

[1023] [1] Nkonya et al. (2016), Economics of Land Degradation and Improvement - A Global Assessment for Sustainable Development."

[1024] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_3746

[1025] https://www.eld-initiative.org/fileadmin/ELD_Filter_Tool/Publication_The_Value_of_Land__Reviewed_/ELD-main-report_en_10_web_72dpi.pdf

Net Present Value (NPV) and the Benefit to Cost Ratio (BCR) of the Soil Health Law, are the following:

- Benefit - avoided cost of soil degradation (Excl. contamination);
- Benefit - avoided costs of soil contamination;
- Cost of implementing SSM practices and restoration measures;
- Cost of identification and remediation of contaminated sites).

For each of these variables, it was considered a minimum value and a maximum value, and computed for these the resulting Net Present Value and Benefit to Cost Ratio (BCR), to be compared to the central estimates, assuming independence between these variables. A lower value for benefits can be considered as due to both actual lower benefits than expected from a full implementation or a reduced uptake of restoration; similarly for costs.

On each occasion when one variable changes, all others remain constant, so as to facilitate the analysis.
The minimum and maximum values that were considered for the sensitivity analysis are the following.

Key variable	**Minimum value** (EUR bn/year, in 2023 prices) central value – 30%	**Central value** (EUR bn/year, in 2023 prices)	**Maximum value** (EUR bn/year, in 2023 prices) central value + 30%
Benefit – Avoided costs of soil degradation (excl. contamination)	35	50	65
Benefit – Avoided costs of soil contamination	17.08	24.4	31.72
Costs of Sustainable Soil Management practices	26.6	38	49.4
Cost of management of contaminated sites (identification, remediation)	37.7	53.9 *(EUR 29 bn for identification, EUR 24.9 bn for remediation)*	70.1

Summary table of results of the sensitivity analysis

The table below provides, for each of the scenarios, the consequences of the changes in the key variable on the Net Present Value (NPV) and the Benefit to Cost Ratio (BCR) of the Soil Health Law, expressed in absolute value, and relatively to the central value.

The results show:

- A strong sensitivity of the Net Present Value and (to a lesser extent) of the Benefit to Cost Ratio to the avoided costs of soil degradation (except decontamination), and to the costs of Sustainable Soil Management practices: the

+/-30% changes in the input values translate into +/-40 to 50% in the NPV and 20 to 40% in the BCR;

- A medium sensitivity to the avoided costs of contamination: the +/-30% changes in the input values translate into +/-20% in the NPV and 10% in the BCR;

- A very low sensitivity to the costs of identification and remediation of contaminated sites: +/-30% changes in the input values translate into +/-2 to 3% in the NPV and in the BCR).

Name of scenario	**Benefit – Avoided costs of soil degradation excl. contamination** (EUR billion/year, 2023 prices)	**Benefit – Avoided costs of soil contamination** (EUR billion/year, 2023 prices)	**Costs of Sustainable Soil Management practices** (EUR billion/year, 2023 prices)	**Cost of identification + remediation of contaminated sites** (EUR billion, 2023 prices)	**Net Present Value** (EUR billion, 2023 prices) (% change vs central scenario)	**Benefit to Cost Ratio** (% change vs central scenario)
Central	50	24.4	38	53.9	320 (0%)	1.69 (0%)
Lower Benefit – Avoided soil degradation	**35**	24.4	38	53.9	**150 (-53%)**	**1.33 (-21%)**
Higher Benefit – Avoided soil degradation	**65**	24.4	38	53.9	**480 (+50%)**	**2.05 (+21%)**
Lower Benefit – Avoided soil contamination	50	**17.8**	38	53.9	**260 (-19%)**	**1.56 (-8%)**
Higher Benefit – Avoided soil contamination	50	**31.72**	38	53.9	**390 (+22%)**	**1.84 (+9%)**
Low Cost – SSM & restoration	50	24.4	**26.6**	53.9	**440 (+38%)**	**2.34 (+38%)**
High Cost – Sustainable Soil Management Practices	50	24.4	**49.4**	53.9	**190 (-41%)**	**1.33 (-21%)**

Name of scenario	Benefit – Avoided costs of soil degradation excl. contamination (EUR billion/year, 2023 prices)	Benefit – Avoided costs of soil contamination (EUR billion/year, 2023 prices)	Costs of Sustainable Soil Management practices (EUR billion/year, 2023 prices)	Cost of identification + remediation of contaminated sites (EUR billion, 2023 prices)	Net Present Value (EUR billion, 2023 prices) (% change vs central scenario)	Benefit to Cost Ratio (% change vs central scenario)
Low Cost – Management contaminated sites	50	24.4	38	**37.7**	330 (+3%)	1.74 (+3%)
High Cost – Management contaminated sites	50	24.4	38	**70.1**	310 (-3%)	1.65 (-2%)

2.2.1.4 Comparison between options

As noted above, there are limitations in the underlying evidence base and approaches to quantifying impacts that have prevented a more detailed assessment of the preferred option. By extension, these limitations also prevent the ability to robustly and quantitatively assess the impacts of other options, relative to the preferred option. These limitations aside, the following table explores qualitatively (and quantitatively where possible for some impact categories) of how the potential impacts of a combined ‘Option 2’ and ‘Option 4’ SHL package could compare relative to the preferred option for illustration.

There is a significant amount of uncertainty in this assessment, but several tentative conclusions can be drawn:

- ***Option 2:*** The benefit-cost ratio of Option 2 could be higher, but also lower or the same as the preferred option (but still likely to be greater than 1). Where fewer sites are identified for remediation or SSM measures implemented, these might focus on those that are most cost-beneficial, leading to a higher BCR. However, this is not guaranteed, as societal payback may be only one factor in the determination of these activities. Additional monitoring network costs will also have a downward effect on the BCR.

  The net present value (or overall benefit) of Option 2 is anticipated to be lower (but still positive) relative to the preferred option. Option 2 is anticipated to lead to less or delayed implementation of SSM, and less activity to identify and remediate CS, both leading to lower costs. But this reduction (or delay) in activity also reduces the benefits achieved through this activity, which reduces the overall net benefit achieved.

- ***Option 4:*** the net present value of Option 4 could be higher, but also possibly lower or the same as the preferred option. Option 4 could lead to greater activity to identify and remediate CS, which would lead to higher costs but also higher benefits. Option 4 could lead to the same or greater costs of implementing SSM, but this could also greater associated benefits. Where the BCR of this additional action is positive, this will extend the net benefit achieved. However, the risks around delivery of a harmonised, EU-wide list of SSM measures could result in no additional benefit, and/or the impact of some of the actions may be detrimental, leading in an extreme case to the NPV of this option being the same or even lower than the preferred option.

  The benefit-cost ratio is anticipated to be lower (but still greater than 1). More CS may be identified and remediated but screening value methods lack sensitivity to important geographic factors, hence there is a high risk that Option 4 could lead to the incorrect identification or sites requiring remediation (identifying more sites), leading to disproportionate costs and less effectiveness. Option 4 may lead to the same or greater effort (and cost to implement SSM). However, if a longer list is defined quickly and not tailored to each Member State, this could lead to action which is ineffective, inefficient and even detrimental, resulting in a lower benefit to investment.

In conclusion, it is possible that one of the economic assessment indicators (NPV or BCR) for Option 2 (BCR) and 4 (NPV) to be more favourable than the preferred option. However, this would only occur in specific circumstances as defined in the table below, and other outcomes are also possible and perhaps more likely. As such, one cannot confidently conclude that either the BCR of Option 2, or NPV of Option 4 would in fact be more favourable than the preferred option. What can be concluded with less uncertainty is that the other economic indicator in each case (NPV for Option 2 and BCR for Option 4) would be less favourable relative to the preferred option. Acknowledging the uncertainty around the relative NPV and BCR assessment, this conclusion adds to the risk and other analysis preformed as part of the impact assessment underpinning the selection of the preferred option.

Table 2-3: Qualitative illustration of the impacts of other options relative to the preferred option (all quantified impacts defined as discounted present value, EUR m, 2023 prices, discounted to 2020, cumulative over appraisal period to 2060)

Effect	OPTION 2* - assessment relative to preferred option	PREFERRED OPTION	OPTION 4**- assessment relative to preferred option
Benefit – avoided costs of soil degradation (Excl. contamination)	Lower *Under Option 2, leaving full flexibility to Member States increases the risk that there will be inconsistency in the implementation and ambition across Member States. Some Member States may either: implement a minimum or limited number of recommendations and restrictions, allow harmful practices to continue without reparation; and/or delay action. Less or delayed action results in lower benefits and the risk that action may not be sufficient to prevent continuing degradation of agricultural, forest and urban soil health. Hence under Option 2 there is a risk of a 'race to the bottom' in terms of ambition across Member States, and a resulting uneven playing field for actors in affected industries and between industries across the EU.*	500,000	Lower, the same or higher (but with lower cost-effectiveness) *Under Option 4, defining a mandated list of applicable practices could lead to more consistent or earlier uptake of SSM measures across Member States, leading to larger benefits. However, a key risk is the challenge associated with defining a list of mandated and prohibited practices that are applicable EU-wide. This risk could manifest in several forms (with different implications for the achievement of benefits):* *- Where an intensive effort is made to define a detailed list which is widely applicable in different scenarios, this could protract the delivery timeframe for the guidance, delaying implementation of SSM, leading to lower benefits.* *- Should a simpler approach be taken, the list of mandated practices could be very short, limiting the additional ambition and impact over Option 3.* *- If a longer list is defined quickly and not tailored to each Member State, this could lead to action which is ineffective, inefficient and even detrimental, and a lack of meaningful implementation (higher benefit, but less cost-effective, or even lower benefit).*
Benefit – avoided costs of soil degradation (contamination)	Lower *Option 2 may be likely to identify the fewest sites for investigation (as Member States would not be held to any common principles) and subsequent remediation, and therefore captures lowest benefits.*	210,000	Higher *Unclear whether Option 4 would lead to the identification of more or less sites, as direct comparison of risk-based methods and soil screening value methods is challenging. Given concerns that soil screening value methods lack sensitivity to important geographic factors, there is a high risk that Option 4 could lead to the incorrect identification or sites requiring remediation (identifying more sites) or incorrect dismissal of sites that need remediation (identifying less sites). While Option 4 cannot be compared in terms of number of*

Effect	OPTION 2* - assessment relative to preferred option	PREFERRED OPTION	OPTION 4**- assessment relative to preferred option
			identified sites expected, it could lead to greater benefits, but also disproportionate costs and less effectiveness.
Costs of enlarged monitoring network	-910 *Option 2 will only achieve partial integration based on available transfer functions and hence would not be able to combine monitoring data from national networks and LUCAS. Member States will need to invest greater resources in additional sampling sites to achieve the required number for reliable assessment.*	-780	-780 *No significant different to preferred option.*
Costs to identify CS	Lower (less negative) *Option 2 may be likely to identify the fewest sites for investigation (as Member States would not be held to any common principles) and therefore could incur lowest costs (but also the lowest benefits).*	-20,000	Higher (more negative) *Unclear whether Option 4 would lead to the identification of more or less sites, as direct comparison of risk-based methods and soil screening value methods is challenging. Given concerns that soil screening value methods lack sensitivity to important geographic factors, there is a high risk that Option 4 could lead to the incorrect identification or sites requiring remediation (identifying more sites) or incorrect dismissal of sites that need remediation (identifying less sites). While Option 4 cannot be compared in terms of number of identified sites expected, it could lead to disproportionate costs and less effectiveness.*
Cost of remediating CS	Lower (less negative) *(As 'costs to identify CS' row above)*	-14,000	Higher (more negative) *(As 'costs to identify CS' row above)*
Cost of implementing SSM	Lower (less negative) *(As 'Benefit – avoided costs of soil degradation (Excl. contamination)'). Under Option 2, less or delayed action results in lower costs, but also the risk that action may not be sufficient to prevent continuing degradation of agricultural, forest and urban soil health.*	-350,000	The same or higher (more negative) *Defining a list of mandated and prohibited practices that are applicable EU-wide could lead to greater (or earlier) levels of implementation across Member States. Should a simple approach be taken, the list of mandated practices could be very short, limiting the additional ambition and cost over Option 3. Where an intensive*

Effect	OPTION 2* - assessment relative to preferred option	PREFERRED OPTION	OPTION 4**- assessment relative to preferred option
			effort is made to define a detailed list which is widely applicable in different scenarios, and/or a longer list is defined quickly and not tailored to each Member State, either could increase costs.
Additional administrative burden – upfront	-29 *Slightly lower cost than Option 3 as:* *- less investment is undertaken to define soil health indicators and districts (but does not reflect consequent risk of variance in the approach to defining thresholds; the number of descriptors for which thresholds are set, and soil health districts, leading to variance in actions taken by Member States to restore unhealthy soils); and* *- no requirement to develop a complete set of transfer matrices to LUCAS (but does not reflect the need to invest more in developing knowledge and resolving issues that stem from a lack of harmonization when comparing across Member States. Also lower costs here offset by higher monitoring costs).*	-34	-89 *Key additional cost linked to obligation for all Member States to develop a soil management plan for all soil districts.*
Additional administrative burden – ongoing	-130 *No significant difference to preferred option.*	-130	-120 *Key difference is Member States and businesses no longer incur costs associated with applications for derogation of remediating CS (noting this does not capture the additional feasibility risks where derogations are not allowed).*
NET PRESENT VALUE	**Lower (but still positive) net benefit** ***Option 2 anticipated to lead to less or delayed implementation of SSM, and less activity to identify and remediate CS, both leading to lower costs. But this reduction (or delay) in activity also reduces the benefits achieved through this activity, which reduces the overall net benefit achieved***	**360,000**	**Lower or the same or higher (but still positive) net benefit** ***Option 4 could lead to greater activity to identify and remediate CS, which would lead to higher costs but also higher benefits. Option 4 could lead to the same or greater costs of implementing SSM, but this could also greater associated benefits. Where the BCR of this additional action is positive, this will extend the net benefit achieved.*** ***However, the cost-effectiveness of this action could be lower than***

Effect	OPTION 2* - assessment relative to preferred option	PREFERRED OPTION	OPTION 4**- assessment relative to preferred option
			under preferred option, but this affects BCR more so than the net benefit. Furthermore, the risks around delivery of a harmonised, EU-wide list of SSM measures could result in no additional benefit, and/or the impact of some of the actions may be detrimental, leading in an extreme case to the NPV of this option being the same or even lower than the preferred option.
BENEFIT-COST RATIO	**Lower or the same or higher (but still >1)** ***Where fewer sites are identified for remediation or SSM measures implemented, these might focus on those that are most cost-beneficial, leading to a higher BCR. However, this is not guaranteed, as societal payback may be only one factor in the determination of these activities. Instead overall cost, or private economic payback may be stronger drivers in the selection and implementation of techniques, which would not necessarily have a higher BCR, and could lead to the same or lower BCR relative to the preferred option. Additional monitoring network costs will also have a downward effect on the BCR.***	*2.00*	**Lower (but still >1)** ***More CS may be identified and remediated but screening value methods lack sensitivity to important geographic factors, hence there is a high risk that Option 4 could lead to the incorrect identification or sites requiring remediation (identifying more sites), leading to disproportionate costs and less effectiveness.*** ***Option 4 may lead to the same or greater effort (and cost to implement SSM). However, if a longer list is defined quickly and not tailored to each Member State, this could lead to action which is ineffective, inefficient and even detrimental, resulting in a lower benefit to investment.***

*Notes: * Selects Option 2 across building blocks, plus LATA1+2 and NUT; ** Selects Option 4 across building blocks, plus LATA1+2 and NUT.*

2.2.2 *Distribution of impacts*

2.2.2.1 Trends by stakeholder type

The different obligations under the proposed SHL (in particular to use soil sustainably, apply the principle of non-deterioration in the second stage, to restore all unhealthy soils by 2050 and to reduce and keep the risk of contaminated sites to acceptable levels by 2050) will fall initially to Member State competent authorities. Hence this is where the impacts (namely the costs) of achieving such obligations, have been initially allocated in the impact analysis. However, in practice these obligations will translate into actions and activities for other actors and stakeholders, who will also therefore share some of the burden.. There is some uncertainty around which actors will be affected and to what extent. This will be driven by a number of variables, including: the delivery mechanisms implemented by each Member State, provision of and access to funding, which soil threats affect different areas to what extent, and what options are available to restore or remediate soil. That said, some high-level conclusions can be drawn around which stakeholders and sectors are more likely to be affected.

The ***costs of sustainable soil management measures***, wider restoration measures and other measures to achieve a nutrients target will somewhat fall on urban and rural land managers and owners who will play an important role in their implementation. This includes land managers and owners in agriculture (e.g., arable, pastoral or livestock, and horticultural), forestry, and other sectors (including urban developments and spaces).

The most significant costs associated with SSM measures are likely to fall on the agricultural sector. Agriculture covers around two-fifths of EU land area[1026] and this soil is typified by active management of soils to support food production, whilst past practises have contributed to soil degradation and exposed soils to multiple threats. This sector is highly exposed due the structure of businesses and the ability to cope with significant capital investments or shocks in financial performance. The scale of area involved and sensitivity on those most impacted by the costs associated with SSM measures lead to a high potential cost burden. As demonstrated by the RECARE assessment[1027] (which identified a wide range of SSM practices applicable to different Member States, different land use systems, and different soil pressures), the costs of such measures per farm or application vary widely, from measures with relatively low cost such as deploying cover crops or crop rotation, to measures with relatively higher costs such as biological soil amendments, and rainwater harvesting. Although not a complete analysis, the illustrative analysis undertaken in this IA of the sample of measures deployed across the EU highlights the magnitude of potential costs: deploying the 5 measures at EU-level suggests a combined illustrative costs of 25.5bn to 34.5bn EUR pa (2020 prices). This compares to a total cost of EUR 20.3bn (2023 prices) estimated by the 2006 IA, of which EUR 19.3bn is anticipated to fall on the agriculture sector.

[1026]https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics#:~:text=Farms%20in%20the%20EU%20managed,for%20agriculture%20(2.2%20%25).
[1027] (PDF) Integrated impact assessment of European soil protection policies (researchgate.net)

Within the agriculture sector, there will also be a differential in costs falling to landowners and land managers, where these are separated (e.g., in an owner-tenant management structure). Given the nature of SSM measures which more often affect how the soil is managed or activities on the land, the majority of any costs would likely fall on land managers rather than landowners. This is demonstrated by the illustrative EU-wide measures: for cover crops the costs entail additional seed purchase, for reduced tillage the cost is a short-term reduction in yield, for organic manures the costs cover spreading (and storage, which could fall either on landowner or manager), and for reduced stocking density it is the temporary cost of boarding animals elsewhere or the opportunity cost of income foregone from additional livestock units no longer present

Significant costs of SSM measures could also fall on forest owners and managers. Forests cover a similar area of land to agriculture (around two-fifths)[1028] but forest soils are deemed less likely to have been intensively managed and degraded over time. That said, forest soils can be exposed to significant degradation when harmful practices are implemented when management occurs (for example during thinning and harvest operations). Costs will again vary by action, ranging from lower costs measures such as post-fire salvage logging to higher cost actions such as implementation of forest residues barriers. However, not all costs will fall to the private sector as around 40% of European forests are publicly owned.[1029] No estimate the costs to the forestry sector has been made as part of the present IA, but of the measure costs estimated as part of the 2006 IA, around EUR 0.7bn was associated with forestry practices to combat soil threats (2023 prices).

Some costs of implementing SSM measures (excluding remediation costs which are considered separately below) may also fall on urban landowners – however these are anticipated to be smaller than those that fall on the agriculture and forest sectors given the land area size is smaller. These costs will also likely be distributed across a wider number of stakeholders and stakeholder types where these are passed through by Member States. This is reinforced by the 2006 IA assessment of costs of measures, which suggested only EUR 0.3bn of EUR 20.3bn costs (2023 prices) were associated with construction practices to combat erosion. Furthermore, urban land use is generally able to generate higher net returns per area and so costs are proportionately lower and more easily absorbed.

Many of the ***benefits of sustainable soil management***, wider restoration measures and other measures to achieve a nutrients target will also fall to urban and rural land managers and owners who implement the measures. This is the case as many SSM measures can result in either a yield benefit or input saving leading to improved productivity in the medium term, although again there will be variance in effect (in general, the positive impacts of SSM practices on yield and or profitability depends on soil type, soil degradation, soil function and type of crop/land use). These benefits are highlighted by the illustrative sample of SSM practices: the five illustrative measures together could deliver an estimated 'on-site' benefit ranging from 17.9bn to 27.5bn EUR

[1028] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20210321-1
[1029] https://www.europarl.europa.eu/factsheets/en/sheet/105/the-european-union-and-forests

pa. For comparison, the estimated range of on-site benefits for the scenario of measures considered in the 2006 IA ranged from EUR 6.1bn – 18.0bn (2023 prices). There will also be yield improvements and input savings for forest owners and managers, although it has not been possible to estimate these here and the evidence base is stronger for agricultural yield improvements. These are again likely to be significant and will vary by location and forest type. There will also be benefits for urban land managers through an improvement in land values.

As with costs, there will again be variation in the benefits achieved by landowners and land managers where these are different. Tenant farmers, contractors, foresters and other land managers who do not own the land they work on may benefit less from the positive impacts on soil health and consequently less economic benefits from improved land values, increases in profitability or yield in comparison to landowners and farmers. This is due to a range of barriers. For example, many agricultural and forestry SSM practices take a longer time to see the positive effects on soil; farm tenures can be short, meaning that they do not see the benefit during their tenancy, and the practice may not be implemented in following tenancies if it changes hands, rendering the existing tenant unable to capture all the benefit given the time limit of their tenancy agreement. Whereas in the case of a landowner managing the land, they may still not capture all the benefits of SSM but would in theory observe and be able to capture an increase in the value of land when their ownership ends.

Alongside the 'on-site' benefits associated with implementation of SSM measures, there will be a range of 'off-site' benefits which accrue to society more broadly. Some will accrue to other businesses - for example, a reduction in erosion of soils will lead to reduction in: costs of sediment removal, treatment and disposal from water courses; costs due to infrastructure (roads, dams and water supply) and property damage caused by sediments run off and flooding; and costs due to necessary treatment of water (surface, groundwater). A partial estimate places the potential size of these benefits in the range from 1.0bn to 18.5bn EUR pa (2023 prices). Some benefits will accrue to citizens living in close proximity to the restored soil, for example a reduction in the risk of landslides – although a total estimate of these benefits cannot be made, the benefit per event avoided is estimated to be 1.7bn EUR (2023 prices). Some of the benefits will accrue to society more generally – for example the carbon sequestration benefit of improved soil organic matter is estimated to be valued between 4.5bn to 12.0bn EUR pa (2023 prices – revised estimate for this IA). Also, investment in additional activities to achieve good soil health and zero pollution will deliver positive employment affects. It is estimated that the sample of 5 illustrative SSM practices could deliver a further 300,000 to 420,000 extra annual working units (AWUs) per annum on an ongoing basis. Furthermore, there will be additional employment benefits as the initial investment ripples through the EU-economy. Including indirect and induced effects, there could be a total 560,000 agriculture AWUs created. Many of these benefits will be captured by local communities.

It is uncertain where the ***costs of investigation, risk assessment and remediation of CS*** will fall (total cost of investigating CS estimated to be EUR 29bn, or EUR 1.9bn spread over 15 years; costs of remediating CS estimated to be around EUR 24.9bn, or EUR

1.0bn per annum over 25 years). Historically around 57% of the costs of remediating sites has fallen on private actors, with 43% falling on public actors. Assuming this split would apply going forward, this implies cost to private sector of 1,110m EUR pa for identification and 569m EUR pa for remediation, and costs to public sector of 830m EUR pa for identification and 429m EUR pa for remediation (all figures are not net of baseline). The private sector costs would be split between different sub-sectors depending on which sites are identified as contaminated and the nature of the remediation measures. Relevant sectors would be distributed across ‘Production Sectors’ (e.g., Oil and Gas, Chemical, Metals and electronics, Pharmaceutical, Mining, Textile, Wood / Paper and Large food and drink manufacturers) and ‘Service Sectors’ (e.g., Gas stations, Railways, Municipal and industrial waste sites, Airports (PFAS), Military bases, Power plants, Construction, Dry cleaning and Outdoor shooting ranges (e.g. on farmland)).

The ***remediation of sites will also deliver significant benefits,*** some of which will accrue to those working on CS and local communicates (e.g., avoided health impacts from exposure to hazardous substances) and some to society more broadly (e.g., additional carbon sequestration and employment). Investigation and remediation could deliver a jobs benefit of 34,000 FTEs over the deployment period – where these effects will fall is somewhat uncertain and will depend on where the skills exist to perform these roles, but some may be captured by existing employees of the sites and local communities. Some of the benefits will accrue to the private sector owners of CS – e.g. with respect to land value, it is estimated that remediation of 166,000 sites across Europe could lead to an ongoing benefit of €12 - €59 million per annum if used for agricultural purposes, or more where the land is used for higher value activities (e.g., housing, commercial property, etc). There will also be other benefits for broader businesses – e.g., a reduction in costs of treatment of surface water, groundwater or drinking water contaminated through the soil. Although not split be impact type, total ‘off-site’ benefits associated with the remediation of CS have been estimated by the 2006 IA and Montanarella (2007) to fall in the range from 3.2bn to 292bn EUR pa (2023 prices), with a central estimate of 24.1bn EUR pa.

Some costs will remain with public authorities. Alongside the costs of investigating and remediating some CS, other costs faced by Member States will include many of the administrative costs of implementing the SHL, the costs of monitoring soil health and soil sealing, and the costs of some restoration measures where it would be more efficient for these costs to sit with public authorities (e.g., development of wetlands) and/or where land (e.g., 40% of European forests) sits under public ownership.

An overview of the potential burden on different stakeholders is presented in the table below. It is important to note that this assessment of impacts is only partial and the true value of achieving soils in good health will be substantially greater.

Table 2-4: Possible split of impact burden between stakeholder types where passed through by Member States (all values 2023 prices)

Stakeholder type	Costs	Benefits
Agricultural land owners and managers (Dairy and arable)	- Majority of SSM costs could fall on agricultural land managers – cost range (based on illustrative sample of measures) of 26bn to 35bn EUR pa (relative to EUR 19.3bn pa costs for agricultural measures in 2006 IA). - Majority of costs fall on land managers – a small fraction could fall on land owners where this is separate.	- Majority of private SSM benefits could fall on agricultural land managers – cost range based on illustrative sample of measures is combined total of 18bn to 27bn EUR pa. - Private benefits will be more evenly split (relative to costs) between land managers and owners where this is separate.
Forest owners and managers (commercial and public)	- Significant SSM measure costs fall on forest land managers. No quantified estimate as part of this IA, but 2006 IA estimated measures costs of EUR 0.7bn pa for forestry sector to combat soil threats. - As agriculture, where separate, majority of costs would fall on forest managers (rather than owners). - If costs follow ownership proportions, majority (60%) could fall on commercial owned forests.	- Significant proportion of SSM private benefits fall on forest land managers. No quantitative estimate. As agriculture, where separate, benefits will be more evenly split (relative to costs) across forest managers and owners. - If benefits follow ownership proportions, majority (60%) could fall to commercial owned forests.
Other land managers (including urban)	- Smaller SSM measure cost (relative to agriculture and forestry). Distributed across wider number of stakeholders and range of stakeholder types.	- Smaller SSM measure benefits (relative to agriculture and forestry) through improved land values. Distributed across wider number of stakeholders and range of stakeholder types.
Business owners of CS – various Production and Service sectors	- Estimated cost to private sector of 1,110m EUR pa for identification and 569m EUR pa for remediation	- Increase in value of regenerated land – estimated ongoing benefit of €12 - €59m pa if used for agricultural purposes, higher for other uses
Other businesses	n/a	- 'Off-site' benefits of SSM (e.g. reduction in sediment removal, or infrastructure repair). Partial estimate places the potential size of these benefits to range from 1.0bn to 18.5bn EUR pa - 'Off-site' benefits of remediation of CS (e.g. reduction in costs of water treatment)
Citizens within / close to areas of poor soil health	n/a	- 'Off site' benefits of SSM measures (e.g. reduction in flooding and landslide risk) – benefit per landslide event avoided is estimated to be £1.7bn EUR. - SSM practices could deliver a further 300,000 to 420,000 extra annual working units (AWUs) per annum on an ongoing basis (based on 5 illustrative practices) - 'Off-site' benefits of remediation of CS (e.g. reduction in health impacts

Stakeholder type	Costs	Benefits
		linked to exposure to hazardous substances)
All citizens	n/a	- 'Off-site' benefits of SSM and remediation of CS – e.g. carbon sequestration benefit of improved SOM estimated between 4.5bn to 12.0bn EUR pa - Investigation and remediation of CS could deliver a jobs benefit of 34,000 FTEs over the deployment period
Public authorities	- Estimated cost to public sector of 830m EUR pa for CS identification and 429m EUR pa for remediation - Estimates for an enhanced monitoring network suggests an additional cost of around €42m pa. - Alongside monitoring, SHL implies additional administrative burden of EUR 1.4m upfront annualised cost and EUR 5.6m pa on an ongoing basis. - Cost of restoration measures where this more efficiently sits with public authorities and/or where land (e.g. forests) are under public ownership.	n/a

2.2.2.2 Difference in effects between rural and urban

The different measures under the SHL will have a different impact in different areas, and hence there is the potential for a variance in impact between rural and urban areas, in particular where the cost burden of meeting obligations is shared by Member States with other actors. Again, given the uncertainty around what restoration and remediation measures will be taken, when and by whom, it is challenging to draw definitive conclusions, but several insights can be drawn.

Sustainable soil management measures, wider restoration measures (excluding remediation of SSM) and measures to deliver a nutrient target are likely to predominantly ***impact rural areas***. Although some measures will be delivered in urban areas, the measures will predominantly impact agricultural and forestry land – this represents a greater land area (around 80% of the EU's land area), soils are more actively managed, nutrients are applied in greater amounts and a lower proportion of rural land is inaccessible. As a consequence, the costs of implementing these measures will also fall more so on rural areas (as demonstrated above, all 5 SSM measures in the illustrative sample fall in agriculture, hence all of the 26bn to 35bn EUR pa range of costs would fall to rural stakeholders). In contrast, the majority of the benefits of implementing these measures would also fall to rural areas. This includes:

- The private SSM benefits (increased yield, lower input costs, improved productivity and resilience) for agricultural and forest land managers – cost range based on illustrative sample of measures is combined total of 18bn to 27bn EUR pa.

- 'Off-site' benefits of SSM to other businesses (e.g., reduction in sediment removal, or infrastructure repair). Partial estimate places the potential size of these benefits to range from 1.0bn to 18.5bn EUR pa
- 'Off-site' benefits to local communities (e.g., reduction in flooding and landslide risk) – benefit per landslide event avoided is estimated to be £1.7bn EUR.
- Employment benefits for local communities - SSM practices could deliver a further 300,000 to 420,000 extra annual working units (AWUs) per annum on an ongoing basis (based on 5 illustrative practices).

Several of the measures are likely to have a greater ***impact in urban areas***. The identification and remediation of contaminated sites will carry with it large impacts – where these will fall will depend on the location of such sites. Many (but not all) of these sites are deemed likely to be located in urban or semi-urban locations - most of the contaminated areas are sites with long histories on the edge of urban centres and/or where urban development has occurred around them, hence the majority of the contaminated soils are likely to fall within / on the perimeter of urban areas. These areas may also be prioritised more highly where a risk-based approach is taken. As such many of the costs of identification and remediation actions may fall in the first instance in these areas. That said, in many cases a single CS will be one site in a wider portfolio, and the costs will accrue to the over-arching business owner, who may spread these costs across its portfolio. Some of the benefits of remediation are more likely to accrue to those working on CS and local communities, and hence urban and semi-urban areas (e.g. avoided health impacts from exposure to hazardous substances). Some will accrue to the private sector owners e.g. increase in value of restored land (although as for the costs, these might not necessarily fall to urban areas). There will also be other benefits for broader businesses locally – e.g. a reduction in costs of treatment of surface water, groundwater or drinking water contaminated through the soil. Investigation and remediation could deliver a jobs benefit of 34,000 FTEs over the deployment period, some of which may be captured by local communities.

In addition, LATA aims to facilitate a solution to the pressure of land take and soil sealing, which is predominantly an issue in urban and semi-urban areas. However, given this only places an obligation to define and monitor this threat, the impacts on urban communities will be negligible. As noted above, some SSM measures will be implemented in urban areas, although their extent and subsequent impacts are likely to be less significant than those implemented in rural areas. That said, urban areas will benefit – ensuring urban soils are restored to healthy condition could encourage more sustainable development of industry, residence, and tourism in urban areas.[1030,1031]

For some components of the SHL, there is a less clear allocation of impacts to either rural or urban areas, in particular where impacts are borne by Member States (e.g. costs of monitoring, wider administrative burden) and/or where impacts accrue to all citizens (e.g. carbon sequestration benefits).

[1030] https://sustainablesoils.org/images/pdf/SUSHI.pdf
[1031] https://webgate.ec.europa.eu/life/publicWebsite/project/details/1817

Table 2-5: Illustrative split of impact burden between stakeholder types

Stakeholder type	Costs	Benefits
Rural	- Private costs of implementing SSM, restoration and nutrient target measures in agricultural and forested soils – illustrative range of 26bn to 35bn EUR pa (relative to EUR 20.0 bn in 2006 IA for agriculture and forest soil measures).	- Private SSM benefits (increased yield, lower input costs) for agricultural and forest land managers – illustrative range of 18bn to 27bn EUR pa. - 'Off-site' benefits of SSM to other businesses (e.g. reduction in sediment removal, or infrastructure repair). Partial estimate ranges from 1.0bn to 18.5bn EUR pa - Off-site' benefits to local communities (e.g. reduction in flooding and landslide risk) – benefit per landslide event avoided is estimated to be £1.7bn EUR. - Employment benefits for local communities - SSM practices could deliver a further 300,000 to 420,000 extra annual working units (AWUs) pa.
Urban / semi-urban	- Cost to private sector of 1,110m EUR pa for identification and 569m EUR pa for remediation of CS (although may be spread across wider portfolios of sites) - Private costs of implementing SSM, restoration and nutrient target measures on urban soils – 2006 IA included cost of EUR 0.3bn for construction practices to combat soil erosion.	- Increase in value of remediated land – estimated ongoing benefit of €12 - €59m pa if used for agricultural purposes, higher for other uses - 'Off-site' benefits of remediation of CS to businesses (e.g. reduction in costs of water treatment) - 'Off-site' benefits of remediation of CS for local citizens (e.g. reduction in health impacts linked to exposure to hazardous substances) - Total 'off-site' benefits of CS remediation estimated to range from EUR 3.2bn – 24.1bn (2023 prices) - Investigation and remediation of CS could deliver a jobs benefit of 34,000 FTEs over the deployment period (proportion of which could fall to local community) - Benefits of restoration of urban soils - encourage more sustainable development of industry, residence, and tourism in urban areas[1032,1033]

2.2.2.3 Impacts on *competitiveness*

The SHL package is considered unlikely to: limit the number or range of suppliers and producers, reduce the incentive of suppliers or producers to compete, nor limit the choices and information made available to customers. That said, there could be a potential impact on competitiveness (and the international competitiveness) through the additional costs that the SHL will place on different types of businesses and stakeholders, and hence potentially on the ability of suppliers to compete. There are two significant costs that will affect different business sectors: the costs of SSM measures, restoration measures and measure to target nutrient loss which will fall predominantly on agricultural and forestry sectors; and the costs of identification and remediation of contaminated sites that will fall on several 'Production' and 'Service' sectors.

[1032] https://sustainablesoils.org/images/pdf/SUSHI.pdf
[1033] https://webgate.ec.europa.eu/life/publicWebsite/project/details/1817

Although it is not possible to precisely estimate the costs of SSM and restoration measures in agricultural and forest land, it is highly likely that there will be a variance in impact across products, sectors and businesses within the EU, and between businesses operating in different Member States. The size of costs will be driven by the levels of soil degradation in different areas used for different agriculture and forest production – in particular the nature and extent of degradation, the nature of actions which can be taken to restore soils and the delivery mechanism implemented by the Member State. Although only one of the variables which will drive costs, the differences between Member States relative to the soil health indicators can provide an illustration of the variance in effects between Member States:

- The proportion of soils with <30mg/kg of P content varies widely across Member States, from 100% of soils in Netherlands to 9% in Greece
- Relatively high N surpluses are found in intensive livestock regions, including: north-western Germany, the Netherlands, Belgium, Luxembourg, Brittany in France and the Po Valley in Italy[1034]
- Only 0.5% of agricultural soils in the Netherlands experience a greater level of erosion than the proposed threshold, whereas 66% of Austrian soils do.
- Some Member States have very low, if not zero, land areas with a SOC/clay ratio of 60% or more relative to the optimum (i.e. Estonia, Finland, Ireland and Lithuania, indicating substantial if not all soils as healthy against this descriptor), whereas some Member States have very high proportions of land falling with a SOC/clay ratio of 60% or greater relative to the optimum (e.g. Spain, Greece and Bulgaria where more than 80% of land is measured to be above the 60% threshold relative to optimum, and hence unhealthy)
- around 3.8m ha in Europe are affected by salinisation , with the most affected regions being: Campania in Italy, the Ebro Valley in Spain, and the Great Alföld in Hungary, but also areas in Greece, Portugal, France, Slovakia and Austria.

Hence there is likely to be a ***greater cost for some agricultural and forest businesses relative to others*** operating in the same market, and also a variance between businesses across Member States. Those operating on healthier soil are likely to face lower, and possibly no, additional costs and hence will be less impacted by the SHL. That said, the benefits associated with SSM measures (productivity improvements, either through yield or lower input costs) will be captured by those implementing the measures and hence will also fall unequally across businesses operating in the same market and between Member States, which will somewhat offset the differential cost burden – albeit productivity improvement benefits accrue with a lag, hence the impact on competition is likely to be more acute in the short-term.

The markets for both agriculture and forestry outputs are international – with imports from outside the EU competing with domestic production in domestic markets, and exports from domestic production competing in non-EU markets. The SHL will place additional costs on EU agriculture and forestry businesses (albeit the size of cost will

[1034] https://www.sciencedirect.com/science/article/pii/S0048969721023548 vary by business) where they need to take action to restore soils. Hence these costs may place a disadvantage on EU-based businesses, in particular in the short term. However, again these same businesses would likely accrue a greater benefit associated with implementing SSM in terms of yield improvements and reduced inputs.

As an illustration of the potential size of effects, it is useful to place the costs in the context of overall market size. In 2020, the gross value added (GVA) of 'Crop and animal production, hunting and related service activities' in the EU-27 was EUR 191bn, whereas the GVA of the 'forest and logging sector was EUR 24.5bn.[1035] The table below presents the various estimates of costs and net costs relative to these GVA figures. For agriculture, taking for comparison the combined cost of the 5 illustrative EU-wide measures (but noting this is not a detailed assessment of the costs of measures which would actually be implemented in practice), the 26bn – 35bn EUR pa range would represent around 13% to 18% of annual GVA, which represents a significant amount. However this is likely to be an extreme estimate – the lower cost estimate of EUR 19.3bn from the 2006 IA would represent a smaller 10% of GVA. Furthermore, when taking into account the benefits which will accrue to the agricultural sector through yield improvements and raw material input savings, the net cost (using the 5 illustrative measures) represents around 4% of annual gross value added, whereas the cost of measures net of on-site benefits from the 2006 IA represents around 1 to 7% of GVA. For forestry, the only estimate of costs is from the 2006 IA, which is equivalent to around 3% of annual GVA for the sector.

Table 2-6: Comparison of SSM costs and net costs to sector GVA

Cost estimate	Metric	Agriculture	Forestry
5 Illustrative measures - cost	Cost (2023 prices)	EUR 25.5bn – EUR 34.5bn	n/a
	%GVA	13 – 18%	n/a
2006 IA - cost	Cost (2023 prices)	EUR 19.3bn	EUR 0.7bn
	%GVA	10%	3%
5 Illustrative measures – net cost	Net cost (2023 prices)	EUR 7bn – 8bn	n/a
	%GVA	4%	n/a
2006 IA – net cost	Net cost (2023 prices)	EUR 1.3bn – 13.2bn	n/a
	%GVA	1 – 7%	n/a

The costs of identifying and remediating contaminated sites could also impact on the ability of some firms to compete. In this case the markets affects are distributed across 'Production Sectors' (e.g. Oil and Gas, Chemical, Metals and electronics, Pharmaceutical, Mining, Textile and Wood / Paper, Large food and drink manufacturers) and 'Service Sectors' (e.g. Gas stations, Railways, Municipal and industrial waste sites, Airports (PFAS), Military bases, Power plants, Construction and Dry cleaning). There is likely to be a variance in impact across products, sectors and businesses within the EU, and between businesses operating in different Member States. The size of costs will be

[1035] Eurostat - NAMA_10_A64

driven by several variables: the number of sites contaminated, the type of contaminant and extent, the options available to de-contaminate the site and the delivery mechanism implemented by the Member State. Hence there is likely to be a greater cost for some businesses relative to others operating in the same market, and also a variance between businesses across Member States.

A key driver of the variation in costs between Member States will be the extent to which Member States have already undertaken activities. For example, 5 Member States are assessed as having completed (Netherlands) or made significant progress (Austria, Denmark, Sweden and Belgium) towards the identification of CS, whereas 8 are assessed as only having made limited progress (Bulgaria, Slovakia, Malta, Slovenia, Portugal, Poland, Ireland, Romania). Likewise there will be a variance in the number of sites needing remediation - the highest number of sites needing remediation may be in: Croatia, Bulgaria, Poland, Cyprus, Malta, and Spain, whereas the lowest number of sites needing remediation may be in: Belgium, Germany, Finland, Luxembourg, and the Netherlands.

In addition, many of the markets within which affected businesses operate are international in nature, and hence EU-based businesses which face costs of remediating sites will be placed at a cost disadvantage relative to extra-EU businesses that import to the EU that do not face similar obligations. Again, one can compare to gross value added as an indicator of the potential significance of such effects – in this case it is challenging to define a combined estimate of all sectors which might be affected. The combined gross value added of 7 potentially affected sectors and sub-sectors[1036] was EUR 507bn in 2020. By comparison, the costs of identification (EUR 1,110m pa) and remediation (EUR 569m pa) which may fall on the private sector (and not taking into account those in the baseline) represent a very small fraction of the gross value added of these sectors – 0.2% and 0.1% respectively.

2.2.3 Impacts on food security and provision of biomass

Two sectors which are likely to be most significantly affected by the SHL are the EU agriculture and forestry sectors. As such, the SHL (in particular the SSM measures) could have important impacts both for food security (around 75% of EU consumption of agricultural output is produced within the EU)[1037] and the provision of biomass, which in turn influences energy security (biomass contributes the main source of renewable energy in the EU (share of almost 60%), with most of the demand met from domestic production (around 96% in 2016)).[1038]

[1036] Mining and quarrying; Manufacture of textiles, wearing apparel, leather and related products; Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials; Manufacture of paper and paper products; Manufacture of coke and refined petroleum products; Manufacture of basic metals and fabricated metal products, except machinery and equipment; Manufacture of electrical equipment

[1037] Relative to a total output value of EUR 408bn in 2016 (Eurostat: aact_eaa01'), total food imports were valued at EUR 101bn with corresponding exports of EU 84bn - https://ec.europa.eu/eurostat/web/products-eurostat-news/-/edn-20171016-1

[1038] https://op.europa.eu/en/publication-detail/-/publication/7931acc2-1ec5-11e9-8d04-01aa75ed71a1/language-en/format-PDF/source-228478685

The extent of these impacts in practice is somewhat uncertain at this stage. The exact type and magnitude of impacts will depend on which SSM measures and measures to reduce nutrient losses are put in place, to what extent and on what agricultural or forestry systems. This uncertainty aside, some tentative insights can be made on the likely nature of the effects, which are likely to be mixed and differ between the short and the medium-to-long terms: whereas short-term effects can in some cases be negative, the long-term effects generally are positive and outweigh these short-term costs by a large margin, specifically in comparison to a baseline scenario where no SSM are taken, and hence soils continue to degrade.

In the short term, some (but not all) SSM measures in certain circumstances can have a negative impact on yield. The 2018 RECARE Impact Assessment[1039] assessed a range of case study examples from across the EU, considering the impacts resulting from varying ambitions of soil management practices. It identified some circumstances where some measures may have an adverse effect on yield, for example, reduced tillage would lead to lower yields when applied to potatoes and sugar beets. This effect of reduced tillage was also identified by Haddaway et al. (2016), where implemented without combination with other management practices, e.g. coverage/residue retention.[1040] In their exploration of the economic impacts of SSM practices Rejesus et al. (2021)[1041] also noted that decreased yield could be a private cost to the land owner, e.g., if delayed planting due to delayed cover crop termination. With regard to agricultural soils, greening obligations under the former CAP (such as ensuring 5% of land is set aside as an ecological focus areas (EFA) or as vegetative barriers) also have potential to reduce farm incomes in the short term, which is down to a result of lost production or constrained production choices. Reductions in yield were identified and quantified as part of the analysis of the illustrative 5 SSM measures implemented at EU-level. For one measure – reduced tillage – reduced yield was identified as a cost, estimated to be in the region of EUR 13bn pa if implemented at EU level.

However, such effects do not hold in all circumstances for specific measures – e.g. RECARE noted that significantly higher yields with no till could be achieved for cereal and legumes. Plus the result of Haddaway et al. (2016) is clearly contingent on the lack of application of complementary methods.

In general, the positive impacts of SSM practices on yields depends on soil type, the initial content of organic matter and type of crop. For many more SSM measures, the impacts on yield are anticipated to be positive. Rejesus et al. (2021) noted that increased yields (and revenues) was also a potential benefit alongside a cost for private land owners. Furthermore, an EJP study on innovative soil management practices across Europe[1042] assessed a wide range of different SSM practices used in Europe across different agricultural, forestry, and other land use systems: for 31 of 35 measures, either

[1039] (PDF) Integrated impact assessment of European soil protection policies (researchgate.net)
[1040] How does tillage intensity affect soil organic carbon? A systematic review protocol | Environmental Evidence | Full Text (biomedcentral.com)
[1041] Economic dimensions of soil health practices that sequester carbon: Promising research directions (jswconline.org)
[1042] Details on the study and the list of SSM practices assessed can be found here: Innovative soil management practices across Europe (ejpsoil.eu)

no or a beneficial impact on yield was identified. However, the study also notes that some practices may have an adverse economic effect, particularly when applied to a particular land use type or soil type where the practice is not suitable and equates to a waste of investment in the practice, or damaged the soil or environment to such an extent that the soil productivity is greatly reduced. Further evidence is presented by a range of LIFE projects. With funding from LIFE, LIFE DEMETER developed a tool, the Decision Support System (DSS), for farmers and their advisors to optimise nutrient and organic matter management simultaneously at field level – uptake is anticipated to lead to an increase of crop production in the range of 5%.[1043]

Hence in the medium-to-longer term, there is strong evidence that the impact of many SSM measures and of the overall SHL will be positive, both for food security and biomass production. For example, Brady et al.'s study on valuing soil ecosystem services[1044] assessed a range of alterative agricultural SSM practices in Sweden which predicted that at the farm-level, an annual 1% relative increase in the stock of soil natural capital delivered through improved management practices over a period of 20 years would result in 18% increase in the average farm's gross margin during the same period. The study also noted that the long-term impacts of (dis)investing in soil natural capital are substantial compared to the short-term impacts, which are small. This is an important consideration for farmers and land managers investing in soil health, as the economic benefits will not be seen for some years. Further, the reality of improving soil fertility ensures that yields become more stable, increasing profit, and there are reduced costs for fertilisers and pesticide use, decreasing costs. This is particularly evident in the longer term.

Indeed, improvements in yield were also captured by the quantitative analysis:

- Improvements in yield were identified as a key benefit for 3 of the 5 illustrative sample measures: cover crops with a benefit of EUR 9.3-9.5bn pa, crop rotation (applied to barley) with benefit of EUR 0.6bn pa, and reduced stocking density with a benefit of EUR 0.6-2.7bn pa.
- The 'on-site' costs of erosion, SOM losses and salinisation assessed in the 2006 IA all focused on yield losses. By restoring soils to good health, the SHL could capture the benefit of avoiding these costs, with an estimated value of EUR 2.2-3.1bn pa (2003 prices). The estimates of on-site benefits were updated to range from EUR 6.1bn to 18.0bn pa in the present IA (2023 prices).
- Improvements in yield also apply to remediation - With respect to land value, it is estimated that remediation of 166,000 sites across Europe could lead to an ongoing benefit of €12 - €59 million per annum if used for agricultural purposes.

Furthermore, these 'static' assessments of yield benefits associated with SSM measures do not capture the 'dynamic' worsening of soil health, and the consequent increasing detrimental impact on yield over time that would occur in the absence of SSM measures. Where action is not taken to tackle soil health, agricultural and forest outputs could

[1043] This benefit has not been transposed into euros / net present value.
[1044] Sustainability | Free Full-Text | Roadmap for Valuing Soil Ecosystem Services to Inform Multi-Level Decision-Making in Agriculture (mdpi.com)

continue to decline, in extreme cases leading to the complete abandonment of land and loss of all output. Hence the greater the level of soil degradation, the greater the benefit for yield, food security and biomass production associated with the deployment of SSM measures, and the greater the medium-to-long term benefits of the SHL (in particular relative to any short term, time-limited reduction in yield in the first year or so after implementation).

2.3 Detailed tables

A summary detailed analysis of the costs of the preferred option is presented in annex 3. More detailed analysis of the preferred option and its benefits and contribution to the Sustainable Development Goals can be found in the following tables.

Table 2-7: Overview of benefits

Building block	Environmental	Economic	Social
Core building blocks			
SHSD – Option 3	• No direct impact. However, defining soil health descriptors, thresholds and districts is a critical facilitating step to determining the action and measures needed to achieve good soil health	• Small, direct benefit through investment in research to refine the ranges and thresholds, which would also involve innovation (not quantified).	• Direct benefit through the generation, provision and use of information and improvements in governance around soil health (not quantified).
MON – Option 3	• No direct impact. However, defining monitoring methods is a critical facilitating step to determining the action and measures needed to achieve good soil health	• Small, direct benefit through investment in research to define the monitoring methods which would also involve innovation (not quantified).	• Direct benefit through the generation, provision and use of information and improvements in governance around soil health (not quantified). Benefit from the increased effectiveness of measures taken to address soil degradation through to improved data and information.
SSM – Option 3	• SSM practices will contribute to the preservation and improvement in the Quality of natural resources, namely soil and to preservation and restoration biodiversity. The size and type of benefit delivered will depend on the actual changes of practice type, its location and extent of implementation (not quantified). • SSM practices can also deliver improvements to air and water quality. For example, cover crops, alongside the key impact of avoiding soil erosion, offers the benefit of mopping up excess nutrients. SSM practices can also retain water and reduce water needs, reduce salinisation and resilience to droughts, and reduce flooding risk (not quantified). • Many SSM practices will deliver a climate benefit - many have the ability to increase soil organic carbon (SOC) and hence the sequestration of carbon, whereas others reduce the use of fuel consumption (not possible to quantify as depends on the type of practice implemented and its context). • SSM practices can also impact positively on Biodiversity, for example for wild pollinators which nest in soils. Soil biodiversity is an indicator for soil health, as it supports the correct functioning of soil processes. E.g., soil organisms, in particular earthworms and arbuscular mycorrhizal fungi (AMF), are positively affected by reduced tillage, which in turn reduces leaching of soil nutrients and loss of soil carbon (not quantified).	• Some SSM practices could deliver economic returns – e.g. through improved yield, reduced fuel or raw materials inputs, or through offsite effects such as reduced water treatment or dredging costs. In certain circumstances, where implemented optimally, some measures may deliver a net positive return. Estimating overall benefits is challenging as this will depend on a number of factors, including the basket of measures selected for and the extent of implementation. Illustrative analysis of a sample of selected measures if implemented EU-wide demonstrate the order of magnitude of effects: cover crops €9.4bn pa; reduced tillage €6-12bn pa; crop rotation €0.6bn pa; organic manures €1.4bn to 2.7bn pa bn pa; stocking density €0.6bn to 2.7 bn pa. Hence investing in SSM will not only improve the sustainability of food production and its resilience but also farmers' incomes • In the longer term, SSM practices work towards avoiding the costs of inaction on soil health, which can be substantial: the costs continued soil degradation have been estimated to amount to EUR 74 billion annually for all 27 Member States. The cost of inaction on soil degradation, which outweighs the cost of action by a factor of 6 in Europe	• Sustainable practices ensure the continued provision of vital ecosystem services such as food and biomass production, water and nutrients cycling, climate mitigation and adaptation, recreation. They reduce the risk and impacts of floods and droughts, of food insecurity crisis, of heat island effects. • Option significantly improves governance around soil health by placing obligation on Member States to use soil sustainably. • Improvements in soil, food, water and air quality all have a beneficial impact on human health (not quantified). • Although the impact varies by practice, some SSM practices can increase labour inputs and hence have a positive impact on employment (not quantified). • Implementing SSM can increase landowner and farmer's skills, knowledge, and expertise, and also networks.
DEF – Option 3	• Indirect impact. Defining contamination status and identifying sites is a critical facilitating step to subsequent remediation activities. The existence of legal instruments has proved to be a determining factor in making progress in CS management.	• Small, direct benefit of levelling the playing field between Member States partly resolving high variance in contaminated site reporting between Member States (not quantified) • Indirect benefit through encouragement of broader changes in land use practices to make them more sustainable and hence contribute	• Direct benefit through the generation, provision and use of information and improvements in governance around soil health (not quantified). • Help local communities suspecting contaminated sites to fulfil their demands and advocacy queries for

Building block	Environmental	Economic	Social
		more broadly to sustainable development (not quantified) • Small, direct benefit through development in expertise in monitoring land contamination to support identification of sites (not quantified)	remediation (not quantified).
REST/REM – Option 3 (/2)	• Restoration and remediation contribute to the preservation and improvement in the Quality of natural resources, namely soil. The size and type of benefit delivered will depend on the practice type, location and extent of implementation (not quantified). • Restoration and remediation practices can also deliver improvements to air and water quality. Restoration practices can also improve water retainment and reduce water needs, reduce salinisation and resilience to droughts, and reduce flooding risk (not quantified). • Some Restoration and remediation practices will deliver a climate benefit – e.g. many increase the capacity of soil to sequester carbon, whereas others reduce the use of fuel consumption (not possible to quantify as depends on the type of practice implemented and its context). • Restoration and remediation practices can also impact positively on Biodiversity. Soil biodiversity is an indicator for soil health, as it supports the correct functioning of soil processes. E.g., soil organisms, in particular earthworms and arbuscular mycorrhizal fungi (AMF), are positively affected by reduced tillage, which in turn reduces leaching of soil nutrients and loss of soil carbon (not quantified).	• Many restoration measures could deliver a positive economic benefit where applied optimally– e.g. through improved yield, reduced fuel or raw materials inputs. Estimating overall benefits is challenging as this will depend on a number of factors, including the basket of measures selected for and the extent of implementation. As illustrated above under SSM, many SSM practices would also deliver restoration of soils to good health. The economic benefits of such measures could run into the €10's billions pa. • Remediation of CS would improve land values of these sites and their potential viability for re-use in other economic activities. Conservative estimates suggest increase in land values could be worth €360m pa where land is used for agricultural uses, more for higher value land uses.	• Public attitudes moving towards climate and sustainability awareness means soil restoration will likely improve social perception of farming and therefore its licence to continue operating (not quantified) • Some restoration practices can increase labour inputs and hence employment, such as needing manual weeding. Remediation activities will also drive economic activity and employment in their deployment (not quantified). • Some restoration practices can offer important improvements in safety and human health risk, e.g. greater absorption of floodwaters in wetlands. Likewise eliminating toxic chemicals through remediation reduces the bioaccumulation of harmful substances through the food chain for both animals and humans (not quantified) • Contribution to sustainable development through delivery of environmental benefits (not quantified).
Add-on options			
LATA1+2	• *No direct impact. But this could have a subsequent, indirect impact on reducing net land take due to better comparison of data across the EU. The indirect environmental benefits of limiting land take, include: climate impacts, overall soil health improvements and related soil biodiversity, and potentially lower risk of flood events due to reduce water runoff from impermeable surfaces.*	• *No direct impacts.*	• *Providing a definition is likely to improve the level and overall completeness of EU-wide data on land take (not quantified).*
NUT1	• *Positive impact on water quality, by improving surface and groundwater quality, thereby lowering risks to human health and biodiversity* • *Improved soil structure and nitrogen planning can reduce nitrous oxide (climate change) by avoiding the conditions that cause nitrogen losses.* • *The measures implemented to reduce nutrient losses may also have a range of complementary environmental benefits.* • *A reduction in nutrient loss will also reduce the amount of phosphorus extracted as a raw material (raw material*	• Many measures to reduce nutrient losses could deliver a positive economic benefit where applied optimally– e.g. through reduced raw materials inputs. Estimating overall benefits is challenging as this will depend on a number of factors, including the basket of measures selected for and the extent of implementation. As illustrated above under SSM, many SSM practices would also deliver restoration of soils to good health. The economic benefits of such measures could run into the €10's billions pa (with overlap with costs identified under SSM).	• *Nitrogen pollution can have impacts on human health, e.g. through air pollution.*

Building block	Environmental	Economic	Social
	savings).		

Table 2-8: Overview of relevant Sustainable Development Goals – Preferred Option(s)

Relevant SDG	Expected progress towards the Goal	Comments
GOAL 2: ZERO HUNGER - End hunger, achieve food security and improved nutrition and promote sustainable agriculture	***Improve (significant)*** – Several options under the SHL package will directly promote sustainable agriculture in the EU – in particular the promotion (and in some cases mandating) of SSM and discouragement (and/or prohibition) of practices harmful to soil health, and also measures implemented to restore soils to good health. Some measures can improve farm revenues and profits in the short term, and in the long term will work towards avoiding soil degradation, abandonment of land and reduction in the productive potential of land and associated food security risk.	It has not been possible to quantify the size of improvement in this study. The size of impact will depend on which measures are implemented in practice, which is uncertain and will depend on the measures selected by Member States and/or the EC under the SSM and REST building blocks. Furthermore, although some data exists around the impacts of some measures on yield in certain circumstances, data on the effects of all practices across all Member States is not available. Analysis of a sample of selected SSM practices illustrates the potential yield benefits under specific circumstances for specific crops – e.g. the analysis assumes cover crops could deliver 7-16% improvements in yield, crop rotation a 5% improvement, and reduced stocking density of 1-12%.
GOAL 3: GOOD HEALTH AND WELL-BEING - Ensure healthy lives and promote well-being for all at all ages	***Improve (significant)*** **–** Several options under the SHL package will directly reduce human health risk. Some SSM and restoration practices reduce air pollution through the reduction in wind-blown dust and other agricultural emissions (e.g. ammonia from use of fertilizer); some improve water quality (e.g. through reducing run off of excess nutrients into water courses) and some reduce the risk of flooding. Remediation actions on CS will reduce direct human occupational health risks, and also reduces the bioaccumulation of harmful substances through the food chain for both animals and humans.	It has not been possible to quantify the size of improvement in this study. The size of impact will depend on which measures are implemented in practice, which is uncertain and will depend on the measures selected by Member States and/or the EC under the SSM and REST building blocks.
GOAL 6: CLEAN WATER AND SANITATION - Ensure availability and sustainable management of water and sanitation for all	***Improve (minor)*** **–** see Goal 3 above related to water quality. However, the improvements are likely to be less significant in this respect, given pollution caused by soil run-off is somewhat captured in waste-water treatment facilities.	See Goal 3 above related to water quality.
GOAL 8: DECENT WORK AND ECONOMIC GROWTH - Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	***Improve (significant)*** **-** Some of the components of the SHL package will place costs on businesses, not least the requirement to implement SSM and restoration practices for farmers, land-owners and land-managers, but also remediation activities to clean up contaminated sites. That said, the general objective of the package is to promote sustainable economic growth. Furthermore, several options will also deliver direct improvements: e.g. the development of soil health descriptors and monitoring processes will promote innovative, and the additional activities under all options could promote employment opportunities.	It has not been possible to quantify the size of improvement in this study. The size of impact will depend on which measures are implemented in practice, which is uncertain and will depend on the measures selected by Member States and/or the EC under the SSM and REST building blocks. Furthermore, although some data exists around the impacts of some measures on yield in certain circumstances, data on the effects of all practices across all Member States is not available (see Goal 2 above for information on yield benefits).
GOAL 11: SUSTAINABLE CITIES AND COMMUNITIES - Make cities and human settlements inclusive, safe, resilient and sustainable *(Specifically: target 11.5).*	***Improve (minor)*** **-** As noted under GOAL 3, the implementation of some SSM and restoration practices will serve to reduce the risk of flooding. Furthermore, although the measure will have no direct effect on land-take, developing a definition and mandating the monitoring of land-take will help improve comparability and tracking of land-take data across the EU.	It has not been possible to quantify the size of improvement in this study. The size of impact will depend on which measures are implemented in practice, which is uncertain and will depend on the measures selected by Member States and/or the EC under the SSM and REST building blocks. Furthermore, no quantitative evidence is available to readily translate the deployment of SSM practices into a

Relevant SDG	Expected progress towards the Goal	Comments
		tangible change in flood risk, which depends on a wide number of parameters.
GOAL 12: RESPONSIBLE PRODUCTION AND CONSUMPTION - Ensure sustainable consumption and production patterns	***Improve (significant)*** **–** As noted under GOAL 8, the package of SHL options will place large adjustment costs on businesses however it will also drive the transition to sustainable economic growth and present employment opportunities. In doing so, it will also promote responsible production in many sectors, not least agriculture and forestry (associated with SSM and restoration measures) and polluting industries (contamination). A core objective of the SHL is the improvement in the quality and efficient use of soil as a resource. Likewise, some of the options will help drive sustainable consumption, in particular PASS1 and the obligation for the proper treatment of excavated soils, which aims to drive greater re-use of excavated soil, created as a by-product of other activities (e.g. development).	It has not been possible to quantify the size of improvement in this study. The size of impact will depend on which measures are implemented in practice, which is uncertain and will depend on the measures selected by Member States and/or the EC under the SSM and REST building blocks. In addition this will also depend on the nature of Member State implementation of the proper treatment of soils.
GOAL 13: CLIMATE ACTION - Take urgent action to combat climate change and its impacts	***Improve (significant)*** - Several options under the SHL package will directly contribute to tackling climate change. SSM (and restoration practices) may help improve carbon sequestration and the level of SOC in the soil; evidence suggests contamination of soils reduces the capacity of soil to absorb carbon dioxide hence remediation activity will work to resolve this; furthermore greater re-use of excavated soils has been shown to reduce transportation distances, costs and associated CO_2 of taking waste soil to landfill.	It has not been possible to quantify the size of improvement in this study. The size of impact will depend on which measures are implemented in practice, which is uncertain and will depend on the measures selected by Member States and/or the EC under the SSM and REST building blocks. In addition this will also depend on the nature of Member State implementation of the proper treatment of soils.
GOAL 14: LIFE BELOW WATER - Conserve and sustainably use the oceans, seas and marine resources for sustainable development	***Improve (significant)*** **–** see Goal 3 above related to water quality. Excess nutrients from soil pose a substantial threat to terrestrial waters in the EU hence SSM practices in particular may help to reduce the amount of run-off from agriculture.	See Goal 3 above related to water quality.
GOAL 15: LIFE ON LAND - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	***Improve (significant)*** **–** Several of the options under the SHL, through their various environmental benefits will work towards improvements against this GOAL. The key objective of the SHL is to achieve good soil health across the EU and the remediation of contaminated sites, which is synonymous with the restoration and sustainable use of terrestrial ecosystems. Furthermore the obligation under SSM of non-deterioration of soil health also links to the protection of these ecosystems. This will be delivered through the combination of options captured under the SHL package – the direct impacts will be delivered through the SSM, restoration and remediation practices implemented, but these will be facilitated only with the implementation of effective options around soil health descriptors and monitoring processes for soil health, and the definition and identification of contaminated sites.	It has not been possible to quantify the size of improvement in this study. The size of impact will depend on which measures are implemented in practice, which is uncertain and will depend on the measures selected by Member States and/or the EC under the SSM, REST and REM building blocks. Furthermore, although evidence exists to suggest that these measures will deliver various environmental benefits, data does not exist which can be used to quantify the level of benefit delivered.

Table 2-9: Rationale for SHL objectives being realistic and proportionate

Aspect of soil degradation MB		SHL objectives for 2050	Rationale for objectives being realistic and proportionate
Loss of soil carbon	Mineral soils	On mineral soils, achieve the SOC/Clay ratio > 1/13 on all soils where this is possible; Member States can apply a corrective factor where specific climatic conditions justify it, taking into account the actual SOC content in permanent	This minimum ratio is considered by science as the minimum value for basic soil functionality for biomass production. As the SOC absorption levels may be low, achieving this ratio may not be possible in all soils. Also, warmer and dryer climate may not allow absorption beyond a certain level. Permanent

Aspect of soil degradation MB		SHL objectives for 2050	Rationale for objectives being realistic and proportionate
		grasslands.	grasslands provide a reference of what is reachable depending on climate and soil type, allowing for a realistic corrective factor. At the same time, all soils can and should contribute to carbon storage in view of the climate targets.
	Organic soils	On organic soils: no target additional to NRL	Unhealthy organic soils would be addressed as an ecosystem in the NRL
Excess nutrients content in soils		Phosphorus: achieve target on phosphorus in all the representative measurement points (MS to select the maximum threshold in the range [30-50] mg/kg); where the target cannot be reasonably reached, MS should ensure that leaching is limited so that water quality respects legal limits.	The objective on phosphorus is formulated to provide a flexible aspirational goal together with a link on targets in existing water legislation . The objective on nitrates levels in soil cannot be set due to variability of the value depending on soil types as well as along the year. However, monitoring of nitrates in soil provide important indications.
Soil acidification		No specific objective	Acidification is expected to reduce as a consequence of actions on nutrients. However, it is important to monitor given the impacts. Soil acidity varies with soil types and it is not possible with current knowledge to set common targets for acidification.
Soil erosion		No unaddressed unsustainable erosion rate or risk above 2 tonnes/hectare/year, considering relevant climate change projections for that area EXCLUDED: Badlands and unmanaged natural areas	Areas where the erosion rate is unsustainable will reduce fertility as well as cause e.g. higher costs in water basins (e.g. removing sediments, water contamination), considering that soil is a non-renewable resource at human time-scale. The erosion risk is requested to be "addressed", leaving full flexibility to decide how to prevent, restoring or compensating (e.g. reducing by soil cover or terracing, changing land use, etc.) The rate of soil formation is estimated, with some uncertainty, at 1.4 tonnes per hectare per year: above this level, the erosion is not compensated by soil formation and is therefore unsustainable; the value of 2 tonnes instead of 1.4 provides a margin that accounts for the uncertainty of the estimation.
Soil compaction		Either the following target is achieved for bulk density of subsoils (in the representative measurement points): Sandy <1.8; Silty <1.65; Clayey <1.47. Member States can replace this with equivalent descriptor and range considering the specificity of soils. or Member States can demonstrate that actions were taken at each adequate level to: - minimize and compensate the loss of ecosystem services due to soil compaction as much as financially and technically possible and - avoid or reduce the pressures for subsoil compaction as	Beyond the threshold set, root growth, and the absorption, retention and filtration of water (and in particular the replenishment of groundwater) are compromised. Subsoil compaction is particularly impacting because invisible and permanent. De-compacting subsoil could be very costly; in case benefits would not be proportionate, MS have full flexibility to take actions that minimize and compensate subsoil compaction as much as financially and technically possible. Heavily modified soils, such as sealed soils or open mines are excluded from this objective. The EEA report "Soil Monitoring in Europe" provides with alternative measurements of compaction.

Aspect of soil degradation MB	SHL objectives for 2050	Rationale for objectives being realistic and proportionate
	much as possible. EXCLUDED: heavily modified soils	
Soil contamination	Reasonable assurance that no unacceptable risk for human health and the environment exist.	MS have the flexibility to decide which is the acceptable level of risk consequent to soil contamination; existing screening values used for soil contamination are extremely different among Member States (up to thousand times) and there exist at this stage no consensus on best values, so no indicative value is proposed
Secondary salinisation	Achieve Electrical Conductivity <4 dS/ m; EXCLUDED: naturally saline soils	At this level of salinization, induced and enhanced by unsustainable soil management practices, the food and biomass production is seriously compromised. The monitoring of salinity will allow to detect where the trend shows salinization and to take mainly preventive measures before it trespasses the threshold
Desertification	No specific objective	Monitoring of desertification is done at UNCCD level, but setting common EU values requires more knowledge. Improvement is expected as a consequence of action on other aspects of soil degradations in particular on erosion, loss of SOC and salinization.
Loss of Water retention capacity	Threshold to be set by the Member States for each soil district and linking with river basins, at a satisfactory level to mitigate the impact of extreme rain or drought, accounting as well for artificial areas (EU guidance to be developed)	MS are left with full flexibility to adapt to local situation and to the level of risk acceptance, as these vary too much to set meaningful values at EU level. At the same time, science allows setting meaningful values at district level depending on the type of soil and the local conditions.
Loss of soil biodiversity	No specific objective	Scientific research does not allow at this stage setting of clear parameters and related thresholds representative of soil biodiversity. Soil biodiversity is expected to improve as a consequence of actions on other aspects of soil degradations, such as. However, it is important to monitor given the key role of soil biodiversity on its functions, such as fertility.
Soil sealing and land take	No specific objective	This would exceed EU environmental legislation. A definition of land take will be proposed to allow common understanding and monitoring of the goals set voluntarily by MS towards the no net land take by 2050 target set out in the 7th EAP and referred to in the EU Soil Strategy.
Total soil degradation	No overall objective	This aims to preserve flexibility to the Member States reflecting the current knowledge as explained above.

3 SME TEST

Step 1/4: Identification of affected businesses

The Soil Health Law defines provisions for Member States, leaving them flexibility in the modalities for the implementation of those provisions. As such, this initiative does not in the first instance target SMEs. However, **this initiative is considered relevant for SMEs**, since the business sectors that are expected to be indirectly concerned by at least some aspects include:

- Agriculture and forestry and related extension services (where micro SMEs such as farmers operate). In the EU, the average farm size is smaller than in the rest of the developed world and small farms constitute the majority of farms. EU small-scale agriculture (which is not necessarily the same definition as for an SME) is often seen as a more sustainable alternative to large-scale farming. (Source: Small farms' role in the EU food system (europa.eu))
- Business activities that have polluted soil (SMEs could be included in these business activities)
- Remediation of contaminated sites (where it is often SMEs operating in this sector)
- Research and laboratories (it is often SMEs operating in this sector)

Step 2/4: Consultation of SME Stakeholders

615 SMEs out of 1093 organizations have replied to the Open Public Consultation on the Soil Health Law: 308 micro (1-9 employees), 156 small (10-49 employees) and 151 medium (50-249 employees) from different sectors, mainly from agriculture (162), environment & nature protection (96), education (47), construction, urban planning & development (27), forestry and hunting (25).

Agriculture	162
Other	129
Environment & nature protection	96
Education	47
Construction, urban planning & development	27
Forestry and hunting	25
Soil remediation	22
Health and social work	19
Waste & waste recycling	19
Food/beverage industry	13
Energy (electricity, gas and water)	11
Mining and quarrying	10
Bio-technology	9
Tourism/recreation	9
Agro-industry (chemical inputs, seeds, machinery)	7
Financial business (bank, insurance, etc.)	7
Disaster prevention	3

To the key question 6 "Do you agree that there should be a legal obligation for Member States to set requirements for the sustainable use of soil", 73% totally agreed; in the agriculture sector, the percentage slightly decreases to 70% and to 69% (46 out of 67) for micro enterprises within this sector. While this represents a majority that fully agrees, this lower value has to be taken into account.

Overall, SMEs consider the initiative as relevant, since 90% of the respondents indicated protection of soil health as a crucial issue (very important and important).
To the question 1 concerning ranking the importance of addressing the protection of soil health at EU level, 79% indicated this problem as a very important; enterprises within education and environment/nature protection sector noted the highest support of the soil health protection importance (96% and 92%, respectively).

On question 7 asking the opinion on a legal obligation for Member States to monitor soil health in their national territory and report on it, 72% of the respondents within all sectors totally agreed. Within specific sectors agricultural enterprises supported this statement in 70%.

Regarding the question 8, whether respondents agree that there should be legal obligations for Member States to remediate contaminated sites that pose a significant risk to human health and the environment, 78% totally agreed, with a lower percentage in the agriculture sector with 62%. Respondents from three sectors: construction, urban planning and development, tourism/recreation, financial businesses totally agreed in 63% with such obligation.

In the opinion of 87% of respondents, the legal proposal should include obligations for Member States to monitor and report on the progress towards the EU objective of "no net land take" by 2050 (totally agree and somewhat agree). Within agriculture sector 73% totally agree. In addition, three sectors: construction and urban planning, tourism/recreation, waste and waste recycling totally agree in 67% on the obligation of the land take monitoring. For environment/nature protection sector, 83% totally agree on the obligation in this regard.

Step 3/4: Assessment of the impact on SMEs

Following the obligations for Member States to assess and monitor soil health, use soil sustainably and restore unhealthy soils, it is expected to be a direct and positive impact on the conduct of business and position of SMEs in the sector of research and laboratories, remediation of contaminated sites as well as in advisory services linked with soil health within each Member State due to the increase in their services and from innovation (e.g. “artificial intelligence solutions from sensing systems” and “field-based measuring systems - hand-held spectrometers, portable DNA extraction, on-site chemical analysis”). (see Annex 9.2 and 11.2). In these sectors, it is estimated that the SHL package could have an associated employment effect of 35,900 FTEs on an ongoing basis over the first ~20 years, of which SMEs are expect to profit.

Following the obligation for Member States to take measures to reduce the risk for human health and the environment to acceptable levels, the SMEs working in activities at risk of pollution could be more vulnerable to additional costs in comparison to larger businesses. For example, large businesses are more likely to have access to other sites in case business activities in a certain location need to cease if the location is identified as a CS, however cessation of activities would likely be very rare. Large businesses may also find it easier to implement and absorb the costs of additional pollution control technologies (which may be expensive); see Annex 9.5.
In case the cost of remediation of contaminated sites falls on private companies, given the significance of costs, there may be important impacts for SMEs and on the sectoral competitiveness, trade, and investment flows of affected sectors as producers in non-EU countries would not be subject to the same costs (see Annex 10.5)

Since the Soil Health Law provisions require a transition from unsustainable management to sustainable management practices, and the implementation of restoration measures where soils are assessed as unhealthy, whenever restoration is possible, small and medium enterprises acting in particular in the agricultural and forestry sectors are expected to face the need for additional resources and face transition risks. At the same time, additional implementation costs are expected to lead to significant employment effects associated (see Annex 9.14). The estimation of these effects presents high uncertainty; however, using illustrative costs and simplistic extrapolation to EU level, it is estimated that 300,000 to 420,000 annual working units (AWUs) could be created associated with implementation of three SSM practices EU-wide on an ongoing basis.

The transition will also often require additional knowledge, in particular to soil managers.

Step 4/4: Minimising negative impacts on SMEs

The preferred option leaves a significant degree of flexibility and therefore discretion to Member States to design the implementation measures in such a way that they minimize any potential negative impacts on business and in particular SMEs. In the timeline and pathways envisaged for the staged implementation of the SHL, Member States would take care that information, knowledge and advice is available to those actors having to implement the transition to sustainable soil management, including information on the funds available (at EU, national and private level). The Staff Working Document “EU funds available to achieve healthy soils” makes public the information concerning the EU funds available in this Multiannual Financial Framework.

The European Green Deal principle of a just transition should be ensured by Member States also for SMEs, by providing adequate measures to mitigate potentially adverse effects.
While the problem of soil degradation needs to be addressed urgently, the target date of 2050 for achieving healthy soils provides a proportionate timescale to realize the transition while phasing it so that adverse impacts for SMEs can be minimized.