European Commission

Proposed Mission

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

Independent Expert Report

Research and Innovation

Caring for soil is caring for life – Ensure 75% of soils are healthy by 2030 for food, people, nature and climate

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EUROPEAN COMMISSION

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Mission Board for Soil health and food

This document is the Mission Board's proposal to the European Commission for a mission in the area of Soil health and food.

2020

Directorate-General for Research and Innovation
Directorate-General for Agriculture and Rural Development

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CITIZEN SUMMARY

***Life on Earth depends on healthy soils**. The soil under our feet is a living system – home to many fascinating plants and animals, whose invisible interactions ensure our well-being and that of the planet. Soils provide us with nutritious food and other products as well as with clean water and flourishing habitats for biodiversity. At the same time, soils can help slow the onset of climate change and make us more resilient to extreme climate events such as droughts and floods. Soils preserve our cultural heritage and are a key part of the landscapes that we all cherish. **Simply put, healthy living soils keep us, and the world around us, alive**.*

*However, we tend to take these benefits for granted and as a result have neglected the health of our soils. The increasing demand for land for urban development and infrastructures is consuming many of our most fertile soils. At the same time, inappropriate or unsustainable use of soil and how we deal with our waste is affecting soil health, which in turn, disrupts the capacity of soils to carry out the vital services that they perform. **Climate change is putting further pressure on soil health**.*

***Why do we need to act now?** Soils are fragile and they can take thousands of years to form but can be destroyed in hours! This means that we need to take care of soils now so that they can be regenerated and safeguarded for future generations.*

*Soil degradation is largely driven by how we live. Left unchecked, it will aggravate many challenges facing the European Union. It is no surprise that **soil condition is at the heart of the new Green Deal for Europe and the United Nations Sustainable Development Goals**, both of which aim to reduce biodiversity loss and pollution, reverse climate change while striving for a healthy environment and sustainable land use. The Mission will also have a **major role in responding to risks from the coronavirus and other emerging infectious diseases**. Some of the microbes which live in the soil are one of our most promising sources of new therapeutic drugs.*

*The mission **"Caring for Soils is Caring for Life" will raise society's awareness of soils and put Europe on a path towards sustainable land and soil management.** The mission will be a joint endeavour, bringing in people from all walks of life, be they farmers, foresters, urban planners, scientists, business communities, politicians or citizens including the consumers, we all are.*

*Together, all of us will help to design and apply solutions to achieve the main goal of the mission which is: **By 2030, at least 75% of soils in each EU Member State are healthy, or show a significant improvement towards meeting accepted thresholds of indicators, to support ecosystem services.***

Mission activities will bring communities together to work with land managers to co-create new knowledge and innovation, training and advice tailored to different local realities. These activities will be focussed around "Lighthouses" and "Living labs", enabling validation and demonstration of good practices and widespread uptake of solutions. In addition, the mission will develop improved ways for monitoring the status of soils, mobilise investments, encourage changes in policies and behaviour and ensure we do ***not export our soil degradation problems to other countries around the world****.*

Through actions that restore degraded land, empower land managers to sustainably use the soil and create the conditions to reward soil health, the ***mission will have wide-reaching impacts on food, people, planet and the climate****.*

While previous missions brought us to the moon, ***Caring for Soils is a mission that will keep us safely on Earth with healthy soils!***

1 The mission explained

1.1 Our vision – what do we want to achieve?

In the context of this mission, soil health has been defined by the Board as "the continued capacity of soils to support ecosystem services[1], in line with the Sustainable Development Goals and the Green Deal".

Life on Earth depends on healthy soils. Soil provides food, clean water and habitats for biodiversity while contributing to climate resilience. It supports our cultural heritage and landscapes. Although as citizens we pay very little attention to soil, it is a fragile resource that needs to be carefully managed and safeguarded for future generations. One centimetre of soil can take hundreds of years to form but can be lost in just a single rainstorm. Even where soil degrades more slowly hidden beneath our feet, the effects are severe and difficult to reverse. Our evidence shows that 60-70% of EU soils are unhealthy. This affects safe food production and what nature provides for humanity to survive.

The proposed mission will shed light on this vital, almost unrecognised resource and **put Europe on a trajectory towards sustainable land and soil management** as part of a wider, green transition. It will be a joint endeavour by researchers, land managers, policy-makers, industry and citizens to co-design, co-create and implement solutions for the restoration and preservation of soils all over Europe.

In terms of policy, the mission will be a main tool for achieving the objectives of the UN Sustainable Development Goals (SDGs) and the EU Green Deal. The Green Deal sets ambitious targets of which the restoration and preservation of healthy soils are key elements. These targets are crucial to ensure that life on earth will still be possible in future years, set against global trends of population growth, climate change, increasing demand for food or loss of biodiversity. The mission will also have a major role in the recovery of the European society from the corona pandemic.

By 2030, at least 75% of soils in each EU Member State are healthy, or show a significant improvement towards meeting accepted thresholds of indicators, to support ecosystem services.

This goal corresponds to an increase in healthy soils against the baseline established by individual Member States and following a bold -Action Plan for soil health.

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[1] By ecosystem services we mean the services provided and the benefits people derive from these services, both at the ecosystem and at the landscape scale, including public goods related to the wider ecosystem functioning and society well-being" (Haines-Young and Potschin 2018; MA 2005)

The mission's proposed indicators for soil health (see Table 1 and section 2.2.) cover measurable physical, chemical, biological and landscape parameters. The measurements will have to follow agreed protocols and thresholds that account for the variability in soil type, land use and climate (see Annex 2) with benchmarks defined by MS themselves.

The need for radical action is based on an analysis of the state of soil health in Europe (Annex 1) which indicates that 60-70% of our soils are unhealthy as a direct result of current management practices. A further poorly defined percentage of soils are also unhealthy due to indirect effects of air pollution and climate change.

In line with the above goal, the mission aims to achieve the following **objectives** and **targets by 2030[2]:**

Objective 1: **Reduce land degradation,** including desertification and salinization.

Target 1.1: 50% of **degraded land is restored** moving beyond land degradation neutrality.

Objective 2: Conserve (e.g. in forests, permanent pastures, wetlands) and increase **soil organic carbon stocks.**

Target 2.1: current **carbon concentration** losses on cultivated land (0.5% per year) are reversed to an increase by 0.1-0.4% per year;

Target 2.2: the area of managed **peatlands** losing carbon is reduced by 30-50%.

Objective 3: **No net soil sealing** and increase the **re-use of urban soils** for urban development.

Target 3.1: switch from 2.4% to **no net soil sealing;**

Target 3.2: the current rate of **soil re-use** is increased from current 13% to 50% to help meet the EU target of **no net land take** by 2050.

Objective 4: **Reduce soil pollution and enhance restoration**

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[2] EU goal, objectives and targets are feasible, but they will require transformations that may not be easy to trigger across all EU regions in the given timeframe.

In citizen engagement events, objectives 1 to 6 where considered relevant with particular mentioning of soil sealing, carbon sequestration and the promotion of organic agriculture

Target 4.1: at least 25% area of EU farmland under **organic agriculture;**

Target 4.2: a further 5-25% of land with reduced risk from **eutrophication, pesticides, anti-microbials** and other agrochemicals and contaminants;

Note: This goes beyond the Green Deal 2030 targets of reducing by 50% the use and risk of chemical pesticides and the use of more hazardous pesticides; reducing nutrient losses by at least 50%; reducing fertilizer use by at least 20%;

Target 4.3: a doubling of the rate of **restoration** of polluted sites.

Objective 5: **Prevent erosion**

Target 5.1: **stop erosion** on 30-50% of land with unsustainable erosion rates.

Objective 6: Improve **soil structure** to enhance habitat quality for soil biota and crops.

Target 6.1: soils with high-density subsoils are reduced by 30 to 50%.

Objective 7: Reduce the **EU global footprint on soils.**

Target 7.1: the **impact of EU's food, timber and biomass imports** on land degradation are reduced by 20-40 %.

Objective 8: Increase **soil literacy in society across Member States.**

Target 8.1: soil health is firmly **embedded in schools** and educational curricula;

Target 8.2: uptake of **soil health training** by land managers and advisors is increased;

Target 8.3: understanding of **impact of consumer choices** on soil health is increased.

The mission's objectives are closely related to those of the European Green Deal and the Sustainable Development Goals, as further explained in sections 1.4 and 1.5. They also align with multiple other EU policies and strategies, as further outlined in section 1.4 (Annex 3).

Through its actions, the mission will have a **wide-reaching impact** not only on soil health but also **on practices in agriculture, forestry and urban areas**. The mission will **improve the functioning of food and bio-based value chains**, the **conditions for biodiversity and the capacity to mitigate and adapt to climate change**. Soil health will clearly be the **starting point for**

systemic transformations across the whole food chain from primary production to food industries and consumer behaviour. Foremost, **the mission will result in society rethinking the ways in which it values and cares about soil**.

1.2 Why do we need healthy soils? The need for a mission

Soils forms the skin of the earth and are essential for all life-sustaining processes on our planet. **Generating one centimetre of top soil takes hundreds of years**. Soils, being a key resource for life on Earth, are also a fragile non-renewable resource in our lifetime. If soils are healthy and are managed sustainably, they provide essential environmental, economic, and social benefits for people. Some ecosystem services provided by soils include:

- producing adequate quantities of **nutritious and safe food**, feed, fibre and other biomass for industries;
- **storing** and purifying **water, regulating flows, recharging aquifers**, and reducing the impact of droughts and floods thereby helping adaptation to climate change;
- **capturing carbon** from the atmosphere and reducing emission of greenhouse gases from soils, thereby contributing to climate mitigation;
- **nutrient cycling** supporting crop productivity and reducing **contamination**;
- preserving and protecting **biodiversity** by preserving habitats both above and within the soil;
- supporting the quality of our **landscapes** and **greening of our towns and cities**.

But **soils are threatened all over Europe and globally**, mostly as a result of human activities. Land degradation is caused amongst others, by unsustainable management practices in agriculture and forestry, contamination from industries and soil sealing through urbanisation and infrastructures. **Food choices**, processes in the food chain and food waste are also affecting soil health.

The following examples from the EU reflect the gravity of the problem (as referenced in Annex1):

- 2.8 million potentially **contaminated sites**, but only 24% are inventoried and 65,500 remediated;
- 83% of EU soils with **residual pesticides**; 21% of agricultural soils with cadmium concentrations above the limit for drinking water; and 6% with heavy metal content potentially unsafe for food production;
- 65-75% of agricultural soils with nutrient inputs at levels risking **eutrophication of soils and water** and affecting biodiversity;
- 2.4% **soil sealed** and only 13% urban development on recycled urban land;

- Cropland soils **losing carbon** at a rate of 0.5% per year and 50% of peatlands drained and losing carbon;
- 24% of land with **unsustainable water erosion rates**;
- 23% of land with high density subsoil indicating **compaction**;
- 25% of land at High or Very High risk of **desertification** in Southern, Central and Eastern Europe in 2017 **-** and an increase of 11% in desertification in just 10 years;
- the **costs associated with soil degradation in the EU exceed 50 billion € per year**[i].

The process of soil degradation can lead to a collapse of landscapes and ecosystems, making societies more vulnerable to extreme weather events, risks to food security, food safety and even political instability. **Land degradation is further exacerbated by the effects of climate change.**

By 2050, 50 - 700 million people worldwide are likely to be forced to migrate due to a combination of climate change and land degradation[ii]. Scenarios for the EU indicate an increasing vulnerability of soils to desertification throughout this century. Climate change may result in structural food shortages by 2050 as many areas become too hot and dry to produce food while fertile soils along rivers and seas may be flooded due to sea level rise. Increased intensities of showers is likely to result in more erosion and landslides. A loss of only 0.1 % of carbon from degraded soils emitted into the atmosphere is equivalent to carbon emissions of 100 million extra cars on the road. Healthy soils, in contrast, are major carbon "storehouses" and essential for mitigating emissions from climate greenhouse gases: more carbon resides in soil than in the atmosphere and all plant life combined[iii]. Polluted soils not only lose their capacity to act as a filter or storage for contaminants such as heavy metals or residues of pesticides but actually can release pollutants, which may end up in the groundwater or may be taken up by plants and thus enter the food chain and pose a threat to food safety. [iv]

Soil health may be lost quickly but is slow to restore and the time for action has already been delayed for too long. It is time to act so that future generations inherit clean, productive and resilient soils.

There is clear evidence management practices can halt land degradation and lead to improvement in soil health with further improvement possible with wider uptake of these best management practices and the development of new innovative practices. Examples include:

- Sustainable management practices halting soil loss in drylands between 20 to 50%[v] and in last 10 years has reduced soil loss by 20% in arable systems[vi]
- Introduction of cover crops increasing soil organic carbon by 6%[vii]
- Adoption of phosphorus loss reduction measures and recycling options reducing phosphorus losses by over 50%[viii]

The mission will provide the **guidance, the means and the critical mass** to direct research, innovation, investments and policies towards **the common goal of restoring soil health in the EU and beyond**. It will be the powerful tool needed to mobilise the whole society in a way that we cannot foresee will happen otherwise.

1.3 A novel approach to soil health

The mission's approach is based on the recognition that:

- It is people and their actions that need to change. Hence the need to **focus on communities** (land managers, citizens, consumers, stakeholders, researchers, advisors, policymakers, industrialists) to **work together**.
- **Soils can only be tackled within a systems' approach**, recognizing its interfaces with land, water and air, which form ecosystems and landscapes; societal needs for food, fibre, nature, industries and the well-being of people; and the fluxes and flows between rural and urban areas.
- **Soils are dynamic, living systems that deliver essential ecosystem services** across farming, forestry, urban and conservation sectors. These services contribute to the SDGs and the Green Deal. They deliver benefits from local to landscape, national and global scale.
- The **diversity of soils and their services needs to be valued** and taken into account in all actions at different scales. This diversity calls for tools and mechanisms that are **adapted to the local context and allow for wider societal involvement.**
- Soil health should be continuously monitored in a harmonised way and the mission proposes a short list of **eight key soil health indicators**. The first six indicators are measured at the plot / field level. Besides the direct, local management, soil health is affected by processes at the scale of landscape, and the two last indicators are measured at the landscape scale (Annex 2).

The proposed mission **is ambitious, bold and urgent** and will deliver **major environmental, economic and social impacts.** It is **relevant for the entire EU territory** in line with the ambition of "leaving no soil behind"! It proposes a novel approach to solving problems of land degradation and addressing the societal challenge of ensuring soil health. The EU has committed itself to preserving soils including through international commitments. The mission is therefore **timely and essential**.

Activities and outcomes of the proposed mission are **measurable and time bound.** Specific land management practices have been defined and new innovative practices will be developed through the R&I programme. All need to be tailored to the different contexts and scales of intervention. Best current management practices need to be implemented now to achieve the **expected**

outcomes by 2030. Progress on success of the mission will be measured by soil health targets and indicators as summarised below in Table 1.

In developing the mission, the board has built on **evidence from data analysis and foresight**. It has taken into account **the views of citizens and stakeholders,** gathered at major events and through a **survey with replies from more than 2.500 participants**.

Table 1: Mapping mission objectives and targets with eight proposed Soil Health indicators

Mission Goal: 75% of all soils are healthy, or show a significant improvement towards meeting accepted thresholds for indicators, to support ecosystem services		
Objectives	**Targets**	**Soil Health Indicators to track outcomes**
1.Reduce land degradation, incl. desertification and salinization	T 1.1: 50% degraded land restored moving beyond land degradation neutrality	*All 8 soil health indicators*
2.Conserve and increase soil organic carbon stocks	T 2.1: current carbon concentration losses on cultivated land (0.5% per year) are reversed to an increase by 0.1-0.4% per year T 2.2: the area of managed peatlands losing carbon is reduced by 30-50%.	*Soil organic carbon stock* *Vegetation cover*
3.No net soil sealing and increase the reuse of urban soils	T 3.1: switch from 2.4% to no net soil sealing T 3.2: Urban recycling of land increased from 13 to 50%	*Soil structure including soil bulk density, absence of soil sealing, erosion and water infiltration* *Vegetation cover*
4.Reduce soil pollution and enhance restoration	T 4.1: 25% of land under organic farming T 4.2: A further 5-25% additional land (i.e. over and above the 25% in full organic) with reduced risk from eutrophication, pesticides, anti-microbials and other contaminants T 4.3: Doubling of the rate of restoration of polluted sites	*Presence of soil pollutants, excess nutrients and salts*

5.Prevent erosion	T 5.1: Stop erosion on 30-50% of land with unsustainable erosion risk	*Soil structure incl. soil bulk density, absence of soil sealing, erosion and water infiltration* *Vegetation cover* *Landscape heterogeneity* *Forest cover*
6.Improve soil structure to enhance **habitat quality for soil biota** and crops	T 6.1: Reduction by 30-50% of soil with high density subsoils	*Soil structure including soil bulk density, absence of soil sealing, erosion and water infiltration.* *Vegetation cover* *Landscape heterogeneity*
7.Reduce the EU global footprint on soils	T 7.1: The impact of EU's food, timber and biomass imports on land degradation are reduced by 20-40%	*Food, feed and fibre imports leading to land degradation and deforestation*
8.Increase soil literacy in society across Member States	Target 8.1: soil health is firmly embedded in schools and educational curricula; Target 8.2: uptake of soil health training by land managers is increased; Target 8.3: understanding of impact of consumer choices on soil health is increased	*All eight indicators (on a long term)*

1.4 Support to the Sustainable Development Goals and to EU policies

To be effective, many players, across sectors, and at various scales need to take action on soil health, from local to European and even global levels. Soil degradation goes hand in hand with an overall decline in environmental quality and threaten the livelihoods of millions of people around the world[ix].

The mission will be a main tool to advance in reaching the targets of the **Sustainable Development Goals (SDGs).** Critically, the SDGs which require action on soil are: SDG2 (zero hunger); SDG 6 (clean water and sanitisation); SDG 13 (climate action) and SDG 15 (life on land). None of these goals can be achieved without improving the status of soils and their management.

Still, neither soil nor soil health are mentioned in the current targets and indicators of the SDGs, except for SDG 15, target 3[3]. The mission board has therefore developed soil relevant targets matching the SDG goals to support monitoring progress towards the SDGs in the EU (Annex 4). The SDGs reflect our commitment to strive for a healthy and sustainable future for people and our planet. As such, it is an integral part of the EU's political priorities as formulated in the Green Deal[4].

The mission will be **key for implementing the Green Deal** and meeting its ambitions to increase the EU's climate performance (SDG 13), achieve zero-pollution (SDG 6 and 10), preserve and restore biodiversity and safeguard our forests (SDG 15) and promote a healthy and environmentally friendly food system (SDG 2). The recently adopted Farm to Fork and the Biodiversity strategies both mention the mission and its "aim to develop solutions for restoring soil health and functions"[x] [xi].

In addition to its central role in Green Deal strategies, the mission will exploit existing tools and instruments and **contribute to EU policies**, such as environmental objectives of the Common Agricultural Policy (CAP), the Water Framework Directive, the Habitats Directive, the Circular Economy Action Plan and the upcoming revised Soil Thematic Strategy. Moreover, it will support global commitments to achieve land degradation neutrality in the EU by 2030.

Finally, the mission will be an essential element of the EU's **post coronavirus recovery package and investment plan,** amongst others through its potential to contribute to major initiatives for soil decontamination, reducing soil sealing, reusing organic waste and carbon farming (see Annex 5).

The mission will contribute to reducing risks from coronavirus and other emerging infectious diseases by enhancing the potential of the soil biome to provide therapeutic solutions to Covid-19 secondary infections. Soil degradation reduces crop productivity and resilience to climate change, but is also likely to release infectious organisms that become air-borne on eroded soils, or survive longer in soils with reduced biodiversity.

Reaching 75% of healthy soils or improving in health in the EU by 2030 will ensure that:

- Soil borne infectious diseases[xii] (Tetanus, Botulism, Polio virus, etc.) are better controlled;

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[3] SDG Target 15.3: By 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.

[4] A European Green Deal as part of Commission priorities for 2019 - 2024: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

- The potential for the soil biome to provide future therapeutic solutions to secondary infections from Covid including antibiotic resistance[xiii] and other biotechnological and medical applications is not lost due to unintended degradation of soil biodiversity;
- EU agriculture resilience to climate shocks is strengthened, leading to reduced risks for food security and food sovereignty;
- Dependency on critical imports of feed is reduced by fostering EU-grown plant proteins on healthy soils, reducing deforestation and hence the risks of infectious diseases emergence.

At a glance: The mission's support to strategic EU targets which underpin the goal of Healthy Soils for Food, Nature, People and Climate

Food: 25% of organic farms by 2030 (Farm to Fork; EU Nature Restoration); Integrated Nutrient Plans (Biodiversity; Farm to Fork); neutral or positive environmental impact of the food chain (Farm to Fork); Recycling of organic wastes into renewable fertilisers (Farm to Fork);

People: Urban Greening Plans and increased reuse of urban soils (EU Nature Restoration and new Urban Mobility Strategy); 25% of organic farms by 2030 (F2F; EU Nature Restoration);

Nature: Protection of land (Biodiversity); Increased circular use of excavated soils (Biodiversity; EU Nature Restoration; Circular Economy, updated Bioeconomy Strategy); Biodiversity friendly soil (Biodiversity); 10% high diversity Landscape features (EU Nature Restoration); Improved protection and targeting for sensitive receptors (EU Nature Restoration; Zero Pollution; Farm to Fork); Protection of soil (Soil Thematic Strategy)

Climate: Certifying carbon removals (Farm to Fork); ensuring the food chain has neutral or positive environmental impact (Farm to Fork).

2 The mission portfolio – scope and building blocks

Through its portfolio, the mission will provide **the vision, the work plan, the citizen engagement and the Research and Innovation (R&I) tools** to re-design production systems and transform the ways by which land and soils are managed.

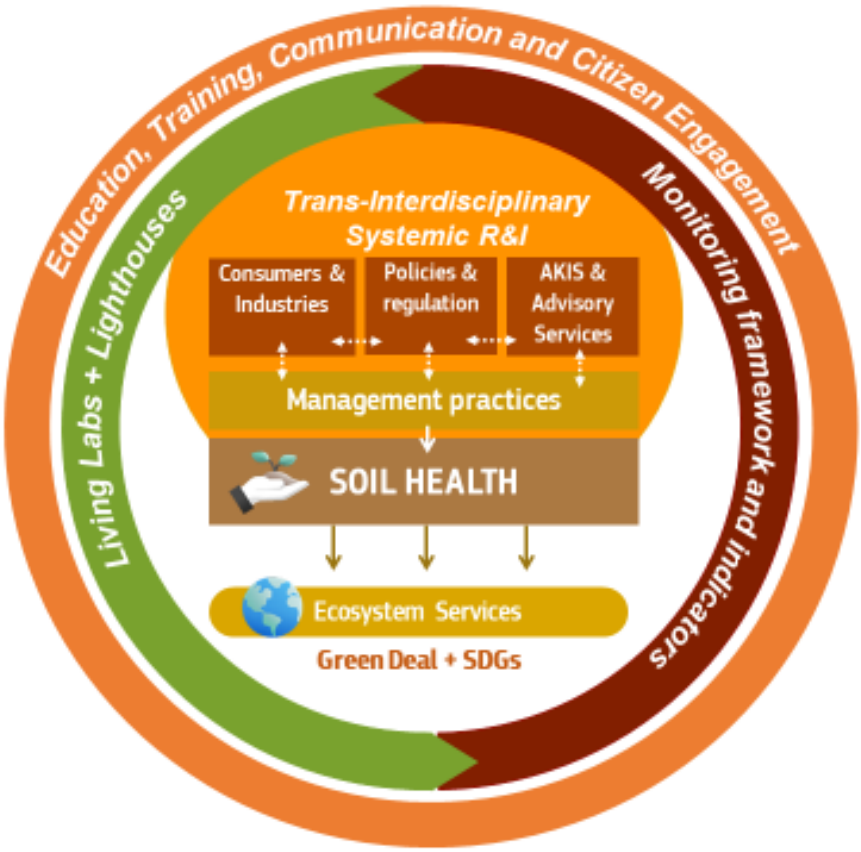

Figure 1: Soil Health drivers and impacts (centre of the figure), and the mission building blocks (in italics)

The mission will deploy a range of activities and tools for **knowledge sharing, co-creation of knowledge and research and for scaling up innovation** to improve soil management; the so-called building blocks. Furthermore, it will **encourage changes to the various drivers of soil health to reverse the trends that have led to soil degradation**.

These drivers include markets and consumer behaviour, policies, incentives and regulation as well as education and advise. The **involvement of stakeholders and citizen engagement will be key in this process**. Figure 1 summarises the rationale and building blocks of the mission.

The **mission's building blocks** are based on

1) **co-creation and sharing** in Living Laboratories (LLs) and Lighthouses (LHs) within and across farms and forest, landscape and urban settings;
2) a consistent selection of eight indicators to be used in a robust **soil monitoring programme** by each Member State equivalent to that for other natural resources (air, water and biodiversity);
3) an ambitious **cross-scale, inter and transdisciplinary R&I programme**;
4) **training, education, communication and citizen engagement** embedded into all activities.

The policy framework, consumer attitudes, market mechanisms and other incentives along with independent advisory services and information platforms for land managers are fundamental drivers of land use and soil management**. The transition towards healthy soils requires that these drivers are addressed as part of the necessary changes that will ensure the success of the mission activities**.

For its implementation, the mission will tap into **various sources of funding at European, national, regional and local levels**. An implementation and investment plan will outline the combination of instruments needed to roll out the mission. This is in line with the understanding of missions as an enabler of changes beyond R&I.

The implementation plan will specify that various EU programmes that could potentially be mobilised to support the mission. It will also address the combination of **public and private funding**, cooperation between sectors and opportunities for **international cooperation**. In carrying out the mission, care will be taken to ensure that all activities, images and language in communications, are **gender inclusive** and that any outreach activities consider a range of accessibility issues.

2.1 Co-creation of knowledge and innovation in living labs and lighthouses

This mission aims to reverse the traditional linear and often disciplinary vision of research and development, by establishing a dense network of "**living laboratories**" and "**lighthouses**" for various types of land uses (farms, forests, industrial areas and urban settings) and functioning very close to land managers and their needs.

Examples of LLs and LHs exist but are not widespread in relation to effective land use systems that combine economic viability with social strength and environmental quality as indicated by ecosystem services provided. A first rapid mapping across Member States helped to identify more than 80 case studies of LLs and LHs and there are likely to be many more. These structures differ substantially in terms of size, history, partnership and area of activities.

Examples include LLs and LHs working on the demonstration of sustainable production technologies, carbon farming, soil and other monitoring systems, and the management of natural resources across farm, forestry and urban systems. While for the time being limited in numbers, these experiences provide a solid, inspirational basis for further developing LLs and LHs at a wider scale.

Living Laboratories (or living labs) are spaces for co-innovation through participatory, transdisciplinary and systemic research. They allow highly committed landowners and land managers, stakeholders from various sectors, public authorities and citizens, including consumers, to work together with researchers from multiple disciplines to develop solutions and identify gaps in our knowledge on soil health. This includes the enhanced use of agroecological principles and of organic agricultural practices that have shown evidence of notable effects on soil health. In living labs there is also research on land managers' motivations, socio-economic drivers, incentive mechanisms, business models and enabling environments for successful transformation towards improved soil health and improved ecosystem services.

Some of these living labs will be **"lighthouses" i.e. places for demonstration of solutions, training and communication.** In the area of agriculture for instance, lighthouses will showcase practices that are exemplary in terms of providing sustainably produced, healthy food, feed or fibre as well as ecosystem services linking rural and urban communities. They will bring together land managers, advisors and citizens, the latter ones having an important role as consumers and drivers of practices in agriculture and the food chain.

Depending on the regional situation, lighthouses and living labs will address specific "needs" for soil health and build the necessary partnerships across spatial scales and value chains. The following characteristics apply to Living Labs and Lighthouses:

<u>Living Labs (LLs):</u>

- **Co-design and co-construction** of innovative practices beyond current understanding with inputs from citizens, practitioners (e.g. farmers, foresters, landscape managers), advisory services, biophysical and social scientists, data scientists and technologists, planners and policy makers, business, educators and trainers. This requires dedicated governance or cooperation models which could also be established at the level of regional clusters of LLs.
- **Experimental** and **research and innovation activities**, moving beyond current management practices that are clearly linked to several of the soil health targets using a systems based approach with clear tracking of outcomes over time using robust monitoring approaches and indicators.
- **Robust scientific approach** embedded taking an interdisciplinary and always when possible, a transdisciplinary approach.
- Wide range of **outreach activities**.

Lighthouses (LHs):

- **Demonstration** of **best management practices** in various sectors and various types of land use which improve soil health and related ecosystem services using a systems based approach.
- **Research** activities focussed around improving current management practices that are clearly linked to one or more of the soil health targets using a systems based approach with clear tracking of multiple outcomes (economic, social, environmental, etc.) over time using robust monitoring approaches.
- Active **outreach and engagement activities** with biophysical and social sciences embedded in all activities to address the quantification of risks and opportunities, cost-benefit analysis, wider systems' impacts including those on food, forestry and urban systems. This shall improve the evidence base and encourage wider uptake both within and beyond the LH boundaries.
- Active **outreach and engagement programmes** to include: high level of engagement activities for citizens (e.g. gardeners, consumers), practitioners (e.g. farmers, foresters, landscape managers), advisory services, data scientists and technologists, planners and policy makers, business, educators and trainers. Support in the co-construction of emerging LLs and LHs within and beyond the immediate regional context.

Living labs and Lighthouses will be grouped within regional clusters of 10-15 units (farms, forests, industrial areas and urban settings) which will allow co-innovation at landscape and watershed levels[xiv]. Networking between these clusters will allow sharing and benefiting from experiences all over Europe.

The ambition is to establish in the first years of the mission **at least five, preferably ten living labs and/or lighthouses in each of the regions[xv] of the EU**. This will result in 1000 – 2000 living labs and lighthouses as incubators and demonstrators of change.

2.2 Efficient soil health monitoring

The effectiveness of different forms of soil improvement can only be assessed by monitoring land use systems at different spatial scales and over time, with efficient indicators. Modern measuring and monitoring techniques, including proximal and remote sensing, offer new opportunities to evaluate the effects of management. Building on closer integration between existing pan-European monitoring instruments (e.g. the LUCAS Soil Module) and Member State national programmes, such data will help to populate performance indicators. The new monitoring system will also **integrate citizen science and crowd sourced data, multimedia and other data** coming from living labs and lighthouses that open-up the monitoring for the citizens. The means for this exist and can be used already.

The mission proposes to use **eight indicators to assess current status and track change**:

1) Presence of soil pollutants, excess nutrients and salts
2) Soil organic carbon stock
3) Soil structure including soil bulk density and absence of soil sealing and erosion[5]
4) Soil biodiversity
5) Soil nutrients and acidity (pH)
6) Vegetation cover
7) Landscape heterogeneity
8) Forest cover

The connection between all these indicators and the objectives and targets of the mission are shown in Table 1 and a justification for their selection and some previous applications are in Annex 2.

The mission argues against a silo approach where only a single indicator is tracked, **as improvement in one indicator should not come at a cost of another. Measurements are soil-specific** showing characteristically different ranges of values for different soil types according to their land use. An unhealthy soil is present if any indicator is below an **agreed threshold defined for that soil type, land use and climate zone**.

2.3 Research needs for soil health innovation

The magnitude of soil health related problems and the urgency to resolve them requires **transformational changes in policy, management practices and a re-design of production systems and land management**. Research and innovation must urgently address all these dimensions. Knowledge exists within individual disciplines but there is hardly any integrated knowledge on soil health combining insights from various disciplines and sectors. To maximise impact, we advocate that R&I activities should be based on the following principles:

- **Systemic approaches:** Recognize soil health interfaces with land, water and air which form ecosystems and landscapes, with societal needs and demands for ecosystem services and with the fluxes and flows between rural and urban areas**.**
- **Interdiscipinarity**: More efficient and fertile integration of scientific disciplines, considering long-term scales, solving problems and taking

[5] Prevention of soil sealing was a main concern voiced by citizens at engagement events

risks, so that innovative approaches can be implemented and results are of high societal relevance. Integration of **natural and social sciences at an equal level** is crucial and a definitive novel step.

- **Transdisciplinarity**: More constant dialogue and co-construction between research and practice, so that the questions addressed by research respond to existing problems, results are tested and validated in practice and improvements can be introduced. The multi-actor approach as promoted by the European Innovation Partnership EIP AGRI as a way to promote transdisciplinarity should be further mainstreamed in research and innovation activities.
- **Contextualization**: Going away from one-size-fits-all approaches and solutions and moving into acknowledging specificities and differentiation. Develop solutions adapted to a particular context, that solve the particular problems and can be applied directly.
- **Societal support**: Co-creation, knowledge sharing, information and demonstration of results to achieve public support for the research needed and activities implemented.
- **Cross-scale** integration: Research and innovation (R&I) activities will take place at a **variety of spatial scales,** addressing the various systems and interactions that have a bearing on soil health.

The LH and LL will be the key structures to identify research and innovation gaps, develop systems approaches and integrated disciplines, in cooperation with practice to **solutions that are ready to be used by practitioners and communicated to citizens at large.** However, many regions lack structures that could support these LLs and LHs, so a gradual implementation is required. It is urgent to start creating LL and LH and provide the support to do so.

The mission proposes a **strong commitment to LLs and LHs across R&I projects**: In regions where LLs and LHs exist and are relevant for the questions to be addressed, the majority of projects should use these structures, or collaborate with them. Where LLs and LHs do not exist or are not appropriate, R&I projects should engage in activities which will lead towards the creation of LLs and LHs relevant to soil health in the near future – so that project act as a dynamo for the creation and development of new LLs and LHs.

This approach will ensure the rapid building of social capital in each EU region with R&I feeding the co-creation of LHs and LLs to catalyse their practical implementation as well as the adaptation to the regional context by learning on-site. It will further allow to appreciate the diversity of initiatives across the EU as a value and an opportunity.

It should be noted that LLs and LHs are not the only approach to R&I, and therefore flexibility will be needed, e.g. when addressing trans-national and global research, EU level policies or soil health monitoring.

As can be seen in Fig.2 based on the example of the agri-food system, there are different, nested scales, interacting with each other. Not all scales where research is needed, can be addressed through LLs and LHs, though.

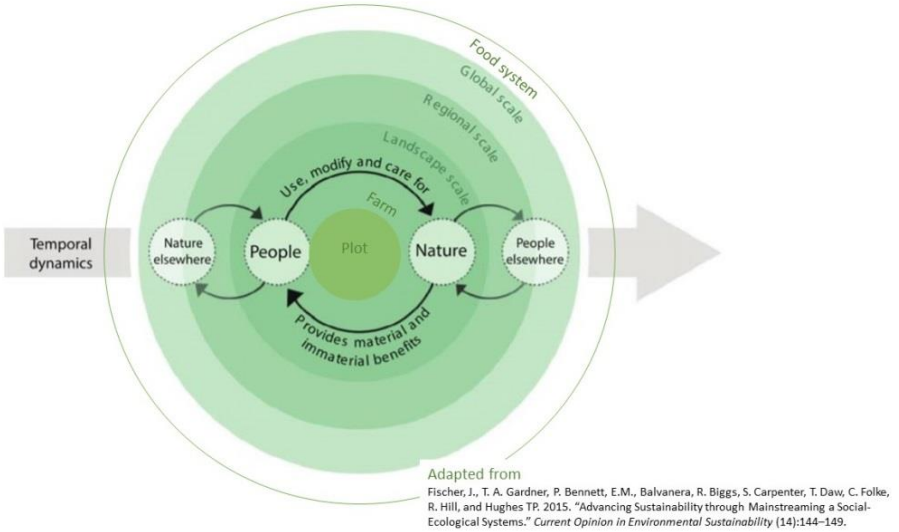

Figure 2 – Nested scales for soil health and food R&I

Plot, farm/forestry/urban, landscape and partly the regional scale can be addressed in close interaction with LLs and LHs. Support to regional and national policies require a further level of integration and strong links with economics and funding issues, and possibly clusters of LLs and LHs and respective actors. Support to national and EU soil monitoring requires a broader scale than the region. The scale of the process(es) at stake is crucial to identify the adequate type of multi-actor construction.

R&I activities will cover the **two fundamental dimensions:**

A. **Research which is focused on SOIL HEALTH** – addressed by multiple natural sciences, including: what is a healthy soil and which indicators thresholds make sense in each context, soil functions and their support to ecosystems services, and how to monitor changes. This includes measurement of the eight indicators of soil health, but could also include measurements of soil functions including ground- and surface water quality, release of greenhouse gas (GHG) and biodiversity. Innovative proximal and remote sensing and monitoring techniques should be further developed to allow rapid but accurate measurements. Increased knowledge is needed to better understand and predict the effects of a changing climate.

B. **Research which addresses the DRIVERS of soil health** – this means soil management and the drivers affecting this management, and requiring social sciences. It includes behaviour analysis of soil managers, understanding the current barriers and opportunities which surround a system change, most efficient mechanisms to support transition to sustainable land use, adaptation of advisory services to different farm and forest structures and factors that lead to success of existing best practices. It also includes assessing changes in practices in the food and non-food value chains and in consumption patterns, or at how urban, and spatial planning could promote a more sustainable use of land.

Different questions to be solved ask for a focus more in one or the other of these two approaches – and this must be supported. A significant part of the funding could go for programmes and projects which are **integrative, paying equal attention to the two domains of soil health and drivers of soil health**.

R&I priorities have been structured according to four headings (P1 - P4):

P1: Integration and uptake of current knowledge.

This is to take advantage of the existing knowledge, including from past programs of EU research funding. Priorities include:

a. Data platforms which integrate and provide existing data in an effective and accessible way. This requires close-collaboration between a range of actors.

b. Linked data and provision of models outputs; long-term field experiments and current monitoring data showing soil health impacts.

d. Identify the social and human mechanisms that, in each socio-economic, political and cultural context, constrain the uptake of already existing knowledge by producers and land managers, e.g. producer's path dependencies, key processes to unlock, supporting mechanisms, , key actors to mobilize and invest in, potential for collective actions; opportunities for efficient spread of innovation.

e. Creation and promotion of Lighthouses to be drivers for the wider uptake of already existing knowledge: e.g. agro-ecological and organic farming practices; conservation agriculture; high nature value farming and land management; carbon farming; sustainable and adaptive forestry, urban planning and greening, urban-rural nexus, information and communication technologies, decision support systems, shorter value chains, improved nutrition and health.

f. Design and improvement of extension and advisory services, adapted to each regional context and targeting all producers and land managers.

Mission objectives supported: 1,2,3,4,5,6.

Scales: Plot and field scale; farm/forest/town & city; Landscape.

P2: Accelerating Innovation in technologies and practices

This is where R&I will focus on innovation and development of new technologies, practices and systems, evaluation of constraints and innovation pathways in social structures, governance mechanisms, value chains, markets and public policy strategies and tools to enable a step change in future management practices to accelerate the rate of meeting the soil health targets. This to include:

a. Living Labs – Co-design and co-construction of demonstration platforms in farms, forestry and urban settings to develop new innovative solutions and integrated local value chains which are immediately tested in a real-world setting. Issues to include diversification, novel crops, cultivars and their combinations; innovative organic and carbon farming; adaptive forestry practices; adaptive practices supporting cropland, pastures and forestry biodiversity; exploration of the rhizosphere and soil biodiversity incl. the microbiome; soil restoration and novel remediation approaches; soil health and food quality; waste valorisation under a circular approach; engagement of urban communities for urban greening.

b. Analysis, new design and monitoring of incentive, markets, financial, regulation and policy tools to provide a robust evidence base of what works where and why with respect to improving uptake of sustainable management practices. Assessment of sustainable business models. Design, test and validate forms of collective actions and place based networks that effectively support changes in practices and business models in farm, forestry and other sectors.

c. Technological projects which develop and make operational new and existing proximal and remote sensing technologies, agriculture machinery and AI. To make more effective and efficient the tracking of soil health change and better implemented and target management practices. Testing within LH and LL where appropriate.

d. Design and validate new forms of collective actions that improve integrated soil, water and waste management at landscape scale[6].

Mission objectives supported: 1,2,3,4,5,6.

Scales: Plot and field scale; Farm/forest/town & city; Landscape.

[6] The need for water and waste management, including home composting, at the local level were indicated as priorities in citizen engagement

P3: Towards global resilience through circular eco-economy and adaptation of food and biomass systems

This to include:

a. Development and testing of foot printing tools which can help assess the global soil health footprint of food and feed, wood and biomass use in the EU.

b. Development of international research cooperation on soil health monitoring, including soil carbon stocks, land degradation, net soil sealing, contaminants and habitat quality.

c. Co-creation of new market mechanisms, business and governance models and training tools that support sustainability in production including soil health.

d. Measuring the influence of agricultural practices (incl. soil management) on yield and crop performance and on the nutritional quality and safety of food and feed

e. Promotion of shorter value chains and circular (bio)-economy to improve soil health, creating rural-urban synergies comprising safe reduction of organic waste

f. Development of supportive policies and incentives for sustainable agri-food systems that improve soil health and reduce their global footprint.

g. Best information, communication, and education mechanisms to the wider public/consumers, and to companies, to encourage consumption of sustainably produced food, biomass and bio-based solutions.

h. Co-design of new community-based models in cooperation with social sciences and humanities towards more sustainable food production, dietary habits, and waste reduction.

Mission objectives supported: 7; support to 1, 2, 3, 4, 5, 6.

Scales: Global and food system; national.

P4: Next generation monitoring and surveillance programmes

This priority is crucial to track progress towards the mission targets. It includes:

a. Creation of a robust pan-EU approach for setting national and regional standards for good soil health (equivalent to that for the Water Framework Directive and other policies) using the suite of indicators defined by the MB. Standards to be created to take account of the

different requirements for soil health by soils type, land use and climate zone combinations.

b. Improvement or establishment of national scale monitoring programmes to track changes in soil health using standardised approach change in soil health to both better support national policies but also local management approaches and to support self-assessment by land managers.

c. Provision of data and services into accessible open data platforms (see 1a above).

d. New modelling platforms to integrate with pan-EU and national soil monitoring, proximal and remote sensing and citizen science.

Mission objectives SHFMB Targets supported: 1,2,3,4,5,6.

3. Training, education, communication and citizen engagement

Barriers for improving soil health include the lack of literacy across all sectors of society as well as the insufficient communication and engagement between communities to create common ground for joint action, evaluation, learning as the mission progresses. Whilst these activities will often be at the local level where people actually live, the success of the mission and the sustainable management of soils will also depend on actions taken by all citizens and not only by experts, as solutions have to be implemented at the European, national, regional. Therefore, to better target these activities, there is a need to better understand the roles of different sectors and audiences who need to change their behaviours and actions, how they interact together, as well as the current barriers and opportunities which surround a system change. The evidence existing or to be produced should be clear about the assumptions being made on communication and engagement processes, and adjusted over time if outcomes are not as intended. This is addressed in section 2 on the R&I priorities.

Here we focus on the specific training and education, communication and engagement activities the mission as a whole should prioritise.

3.1 Training and education

The mission acknowledges that for society to rebalance its perception of soil, education must be at the heart of this change. Education is not simply the accumulation of knowledge, but it supports competencies that allow the application of that knowledge to move forward. Education allows citizens to share the need for protecting soil and articulate this need vis-a-vis decision-makers.

In this context, the mission should be a stimulus to increase the emphasis placed on soil in education, promote integrated research on soil (especially in links with

other missions), encourage more and better learning opportunities for society at large, and reward best practices. Due attention will be given to improving access to evidence based information and adequate access to advisory services as well as to making full use of new opportunities for education arising from digitisation.

Examples include:

- Soil science curricula should especially be developed for schools, adapted to different age groups. Such curricula should be stimulating, fun, practical and provide a combination of theoretical and practical learning for scholars to understand the importance of soil in their daily existence;
- At University level soil science should include training on the use of systemic approaches, technical advances and information for accurate advice by the future graduates, to land managers and policy makers.
- Educational gardens in schools and parks, farm open days, study clubs, as well as new online technologies can be used to link and demonstrate food production, soil biodiversity, nutrient cycles, etc.;
- Links between soil and key societal concerns (e.g. cancer, climate change, ocean health, food safety, pollution, etc.) can be made clear in educational programmes, when these key concerns are addressed.
- Member States should ensure adequate access to advisory services and refresher courses to help farmers, foresters and managers of urban green areas to implement sustainable soil management practices.

3.2 Communication and citizen engagement

Communication (here intended as a one-way flow of information from the sender to the receiver) and citizen engagement (here intended as a participatory process with a two-way flow between the sender and the receiver and vice versa) are key elements of the mission and crucial for its success.

People at large are often not fully aware of the manifold functions of soils and the relevance of these functions for humankind. Communication activities throughout the mission will bring soils closer to the attention of citizens and stakeholders while engagement activities will allow citizens to be a main player in the mission process.

Living labs and lighthouses will be main vehicles for citizen engagement, bringing together researchers, practitioners, communities and other stakeholders to develop together solutions with a tangible impact and to share and spread already existing sustainable practices.

The numerous events with the involvement of citizens throughout 2020 (see table at the end of Annex 7) were a very positive experiences that were taken into account when setting up this mission proposal. They showed that citizens can bring enthusiasm and meaningful inputs to discussions on R&I and its implications

for citizens' daily lives. There is a true and genuine appetite for participation, as shown for instance by the fact that 80% out of about 2.500 respondents to a European wide online survey (running from December 2019 until September 2020) replied that they would like to engage in actions to improve soil health.

In Czechia and Portugal, where workshops followed an agreed methodology for engagement, citizens raised very precise views on what they consider as priorities for action under the mission. This included issues addressing soil sealing, water and waste management, reforestation, support to (small) farmers for sustainable practices (also to go away from the production of biofuels) and the need for better governance, information and monitoring. The priorities identified reflect well local needs and specificities and are highly valuable for the differentiation of LLs and LHs in regions.

At a workshop with the European Youth Forum, students and young professionals showed that they are well aware of soil threats. Their concerns were the prevention of soil ceiling, more efficient support to farmers and foresters for soil friendly practices, increasing (soil) biodiversity in urban and rural areas strengthening organic production.

Living labs and lighthouses will contribute in each Member State to the provision of a soil information hub of the 'best of' resources including: soil health data; video and education tools; activities to learn how to protect and restore soil health; information to source accredited approaches for Continuous Professional Development (CPD) for land managers; information on locations and activities of living lighthouse and living laboratories in the Member State and across the EU.

The Mission Board has developed a draft communication and citizen engagement strategy. It is a living document that will be further refined and constantly updated throughout the missions' implementation to take into account progress of activities, and specific needs arising. In addition, and as a starting point for further communication, this mission report includes a "citizens' manifesto", summarising the essence of the mission proposal (Annex 8). This manifesto will be further developed and updated during the implementation phase of the mission.

For its communication activities, the mission will make use of a rich landscape of local, regional, national and European networks working in the mission area, as well as educational institutions.

It will team up with citizen science initiatives, such as the European Network for Soil Awareness, the European Citizen Science Association or the Future Earth Knowledge and Action Network on Systems of Sustainable Consumption and Production.

The European Innovation Partnership EIP AGRI will be a main tool to reach out to the agricultural and forestry sector. The mission will feed into the EU Soil Observatory and reach out to international partners, e.g. through the Global Soil Partnership and its Healthy Soils Facility.

4. A supportive environment for healthy soils and societal benefits

4.1 Creating enabling conditions

Research, innovation, demonstration and monitoring alone will not be enough to mainstream improved soil management throughout Europe and achieve the ambitions of the mission.

Public policies, incentives, investments, information, advice and society at large, need to be mobilized to create an enabling environment for the sustainable management of soils. All of us as consumers will have a central role to drive for the change needed[7].

The following list shows main priorities for action which will be pursued as part of the wider activities of the mission to act on drivers of soil health. It is complemented by an overview of possible funding programmes and instruments that could be mobilised to support mission activities (Annex 7):

(i) **Policies and legislation** to be harmonized to support sustainable soil management and regenerative, circular bio-economy value chains;

(ii) **CAP new payment schemes** to reward effectively practices that improve and restore soil health through more diverse, regenerative and systems-based approaches in agriculture and forestry based on long-term contracts and compensation for results measured by the level of ecosystem services provision

[7] Consulted citizens declared for example that they wished to be able to distinguish among products to opt for "soil-friendly" products.

(iii) **De-risking and guarantee mechanisms** for land managers and businesses that engage in transformation towards increased soil health, such as long-term loans guaranteed by a specific financial organisation.

(iv) Regulations and taxes that reward the **purchase of goods** produced in a manner that improves soil health;

(v) A new **Soil Thematic Strategy and Directive** to be developed to provide a regulatory framework enabling changes as defined by mission roadmap and robust aligned soil monitoring programmes by each MS;

(vi) **Spatial planning** to reduce and possibly reverse soil sealing by stopping urban sprawl and the occupancy of soils by transport infrastructures and enhance mosaic landscapes;

(vii) Context specific **Knowledge and Innovation Systems** (AKIS), including specific advisory services which links to individual land managers, to be designed, tested and validated;

(viii) Online, easy to use, **multiple language platforms** to access and share knowledge and experiences;

(ix) **Changes across food systems**, including at transformation, retail and consumer level, to be fostered to provide the 'market pull' to drive the changes needed;

(x) **Public and private sector investments** in R&D to foster sectoral innovations for soil health monitoring and improvement, including regional innovations led by cities and regions for couples transformation of soil health and food systems, or waste management systems.

4.2 Synergies with other missions and EU programmes

Soils play a central role in addressing major challenges on climate change, biodiversity, food production, food safety and water management.

This was recognised by the President of the European Commission, Ursula von der Leyen, when outlining her vision for a greener Europe: **"Climate change, biodiversity, food security, deforestation and land degradation go together".**

The Soil Health Mission will have important spill overs on other missions and contribute to

- Healthy Oceans, Seas, coastal and inland waters: by reducing pollution from fertilisers, pesticides and other contaminants;
- Climate Adaptation and Societal Transformation: by enhancing carbon and biodiverse rich soils as the basis for climate resilient agriculture and rural landscapes or by raising citizens and land managers awareness to the need for a transformative change in land use practices;

- Climate Neutral and Smart Cities: by reducing and progressively stopping soil sealing and enhancing soil health of city soils, contributing to the greening of European towns and cities and a better urban environment;
- Cancer: by promoting safe (non-polluted) food and healthy diets as an important element of cancer prevention.

The mission will equally benefit from activities carried out by the other missions, e.g. in the context of regional and urban activities for climate adaptation. **Cooperation between the five missions is therefore required.**

As part of the mission's plan for implementation, synergies will be established with a number of EU programmes and EU infrastructures including:

- EU Horizon Europe partnerships on (1) agro-ecology and (2) food systems; Horizon Europe activities under Cluster 6 and other parts of the Horizon Europe programme under Pillars I and III;
- EU infrastructures;
- H2020 projects : European Joint Programme EJP Soils[xvi] and CIRCASA[xvii];
- EIT Climate Knowledge and Innovation Community[xviii] and EIT Food[xix]
- JRC activities, e.g. in the context of the EU Soil Observatory as a repository of mission outcomes and of LUCAS soil[xx];
- European Space Agency (ESA) for World Soils and Society - Thematic Exploitation Platforms on Food Security, Forestry, Coastal, Urban[xxi];
- Copernicus programme (Land Monitoring, Climate Change and Emergency Management Services);
- Pro Silva– Integrated forest management for resilience and sustainability[xxii].

By connecting activities and seeking for synergies between various programmes, initiatives and infrastructures, the mission will enhance the sharing of knowledge and innovations, speed up the widespread uptake of solutions and increase impact of activities.

4.3 Timeline of activities

Activity / Year	'21	'22	'23	'24	'25	'26	'27	'28	'29	'30
CO-DESIGN PHASE										
1. Identifying and mapping in each EU region: (1) "soil needs", objectives and priorities for action; (2) structures for implementing mission activities, (3) funding & other mechanisms for setting up living labs (LLs) and lighthouses (LHs)										
2. Building communities at different spatial scales and levels										
CO-IMPLEMENTATION PHASE										
Setting up and running regional LLs and LHs across regions in Europe; building clusters and networks										
Carry out R&I activities to support objectives of the mission										
Training and access to independent, advisory services for all land managers										
MONITORING AND CO-ASSESSMENT										
Support development of monitoring systems in Member States according to agreed, validated protocols and identified benchmarks										
Mid-term evaluation of activities										
Monitor mission activities and outcomes for improved soil health										
CROSS-CUTTING, ENABLING ACTIONS										
Communication and citizen engagement										
Science-policy dialogue and other activities to address drivers of soil health: e.g. policies, soil legislation, regulation and taxes for food, global foot-printing tools										
Support to (Agricultural) Knowledge and Innovation Systems										
Data (e.g. freely available data products), information and support to an EU Soil Observatory										

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[xiv] https://www.macs-g20.org/fileadmin/macs/Annual_Meetings/2019_Japan/ALL_Executive_Report.pdf 016/j.envint2019.105059

[xv] Regions are defined according to the NUTS 2 classification: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02003R1059-20191113&from=EN

[xvi] EJP Soils: (https://projects.au.dk/ejpsoil/about-ejp-soil/)

[xvii] CIRCASA: https://www.circasa-project.eu/

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[xxii] ProSilva: www.prosilva.org

ANNEXES

Annex 1 Review of the evidence base: status of soil health across Europe in 2020

This document represents a review of the latest literature by the Soil Health and Food Mission Board (MB) and the European Commission's Joint Research Centre (JRC) to help define **the main goal of the mission**: namely, **that 75% of the soils of the European Union (EU) should be healthy or improving by 2030**. The review concludes:

A review of the current evidence of the state of EU soils by the MB and JRC is that current management practices result in, approximately, 60-70% of EU soils being unhealthy, with a further, as yet, uncertain percentage of soils unhealthy due to poorly quantified pollution issues. A 75% goal of healthy or improving soil by 2030 through a radical change in current land management practices is both feasible and necessary. Soils will also benefit from improvement to indirect drivers of change such as reductions in air pollution and carbon emissions.

The following sections provides the evidence base for this statement.

Some basic assumptions:

- EU Land area: 4,233,255 km^2
- Agricultural area of EU is 39% of land area: 1,730,000 km^2
- Croplands occupies 23% of the EU: 1,060,000 km^2
- Artificial areas occupy 5% of the EU: 222,592 km^2
- 'Natural' soils (i.e. without intensive management regimes): 52% of the EU

1. Nutrients

The Gross Nutrient Balance Indicator (EUROSTAT 2020) shows that there is currently an excess of fertilizer applications in the EU: data show that for agricultural land there is a surplus of 50 kg N/ha and 2 kg P/ha.

The European Commission (EC 2018) reports that Nitrates Vulnerable Zones (NVZ) cover 2,175,861 km^2 of the EU (latest figures for 2015 and includes MS that apply a whole-territory approach). NVZ represent approximately 61% of agricultural land. This means that there are obligations to reach a balanced fertilisation for 61% of agricultural soils (arable and grasslands).

SOER 2020 (EEA) reports that for 65-75% of agricultural soils, nitrogen values exceed critical values beyond which eutrophication can be expected (De Vries et al., in prep).

There are also issues from atmospheric deposition of nutrient nitrogen in non-agricultural systems. CIAM/IIASA (2018) reported that critical loads for

eutrophication were determined for 2.65 million km^2 (62%) of European land in 2017. (See also Section 6 on Contamination).

Therefore, area of land with failure of soil health indicator due to direct inputs nutrient issues in agricultural systems (excluding air pollution issues) = 27% – 31.5%

2. Organic carbon

LUCAS Soil data, covering surface soil, show that cultivated and permanent crops have the lowest SOC concentrations of all major land cover classes (around 17 g/kg C). By comparison, average levels for permanent grasslands in the EU are 2.4 times higher (Hiederer 2018).

Most croplands in EU are most likely to be already at sub-optimal levels – 1.5% of all land use have SOC levels below 1% C. This rises to 2.6% of arable soils (JRC LUCAS). This would account for approx. 0.6% of land outside of agriculture.

LUCAS soil organic carbon concentration change analysis (2009-2015) for points where land cover was the same in both dates, show a decrease of about 0.5 % per year on croplands which was statistically significant on the most carbon poor soils (Hiederer 2018). Subsequent estimates of overall SOC stock changes (all soils) indicate that the total SOC change between LUCAS 2009/12 and 2015 show that about 60 % of EU agricultural areas experienced changes below 0.2% of the average stock. The trend in in carbon stocks in grassland was loss of about 0.04 % and in arable land a loss of about 0.06% (Panagos et al 2020). 10% of the area is predicted to have changes larger than ± 12 g kg^{-1} over the 6 year interval

Area of land with failure of soil health indicator due to low and declining carbon stocks = 23% (BUT there will be overlap with (1)). 0.6% falls outside of agricultural areas.

3. Peat

Byrne et al. (2004) reported an area of 340,000 km^2 of peat soils in the EU Member States and Candidate Countries (Tanneberger et al.2017, has updated figures on extent per country, which indicates that the extent of peatlands in the EU is closer to 270,000 km^2, although the figures for some countries are still approximations). On this basis, peats cover 8% of EU land area, of which 50% of peatlands are estimated to be drained which will result in the oxidising of the peat and loss carbon to the atmosphere (JRC 2016). Results from hydrological reconstructions indicated 60% of peatlands are drier than they were 1000 years ago due to these direct human impacts and climatic drying (Swindleset al. 2019).

Not all peat being degraded is under agriculture. Schils et al., 2008 estimates about 20,000 km2 of drained peat (ca. 7.4% of peatland) is not in agricultural use as cropland or grassland (0.5% of EU).

Area of land failing soil health indicator due to peatland degradation = 4.8% under (1) or (2) but 0.5% is outside agricultural areas.

4. Water Erosion

Pangos et al. (2015) reports that 24% of land has unsustainable soil water erosion rates (>2. t /ha). Mean soil erosion by water for EU is 2.46 t ha^{-1} yr^{-1}, resulting in a total annual soil loss of 970 Mt. This covers a wide range of land use types with around 70% of the land in agricultural systems. This means that area not overlapping with (1) and (2) could be estimated as 17% (47% of 24% eroding land).

However, a new report by JRC (Panagos et al. 2020) shows erosion by water on arable land is 10% greater than the mean for the EU (this means that we can consider all 23% of cropland as affected). Permanent crops have highest soil erosion rates. Arable and permanent crops cover 30% of EU land.

In addition, there are notable erosion rates on shrubland and sparse vegetation with mean soil loss rate of 2.69 t ha^{-1} yr^{-1} and 40 t $ha^{-}1$ yr^{-1}, respectively. Together, these land cover types occupy 30.8% of the EU (not under agriculture).

A JRC erosion model (Borelli et al. 2017) shows wind erosion in EU is 0.53 Mg ha^{-1} y^{-1}. 9·7% of arable land has problems with wind erosion, with 5·3% and 4·4% displaying moderate and high rates of wind erosion, respectively. However, these will fall in the above estimates of agricultural land.

Area of land failing soil health indicator due to soil erosion = 23% in cropland and 30% in non-agricultural areas.

5. Compaction

There are very uncertain numbers for compaction. Based on partial data coverage for the EU (modelling of representative soil profiles), the best available estimates suggests that 23% of land assessed had critically high densities (JRC 2016). JRC 2009 estimated that 33% of soils are susceptible to compaction, of which 20% moderately so. The issue is more likely in agricultural soils but it is also found in organic-rich forest soils so some overlap with (1) and (2). Confirms the multiple pressures on soil.

Area of land failing soil health indicator due to soil compaction = 23-33%, 7% of which are outside agricultural area.

6. Pollution including risks to food

There are many unknowns especially in relation to diffuse soil pollution in natural landscapes (i.e. 52% of EU) and there are more than 700 recognised soil pollutants (NORMAN, 2014).

In terms of local soil pollution, JRC (Paya Perezet al. 2018) reported 2.8 million potentially contaminated sites in EEA-39 but the area of land is not known. There is no standardised agreement on a definition of contaminated sites which can range from petrochemical plants to petrol stations. An indicator on "Progress on the remediation of contaminated sites" is based on risk assessment approach where efforts are mainly focused on investigation of sites where polluting

activities took/are taking place. The report noted the occurrence of 650,000 registered sites where polluting activities took/are taking place in national and regional inventories. 65,500 sites have been remediated.

The Cocoom InterReg Project estimated that there are more than 500,000 landfills in EU. 90% are in regarded as non-sanitary landfills (i.e. predating the Landfill Directive (1999)). NASA estimates that the average size of landfills in US is 200 ha. Even if we take just 10% of that value for EU, it would mean that landfills occupy 100,000 km^2 (2.3%) of EU territory (no actual figures exist).

The situation is more complex for diffuse pollution. Numerous studies show the impact of pollution on soil but it is difficult to assess area or extent. For example, there are no data on the extent of pesticide contamination, POPs, microplastics, veterinary products/pharmaceutical, emerging concerns such as pFAS. Pimentel & Levitan (1986) reported that 3,000 types of pesticides have been applied in EU agricultural environment during the past 50 years. They estimated that less than 0.1% of the pesticide applied to crops actually reaches the target pest. Of LUCAS soils tested, 83% of soils contained one or more residue of pesticides and 58% contained mixtures. (Silva et al. 2019).

De Vries et al. (In prep) and cited in EEA (2020) state 21% of agricultural soils have cadmium concentrations in the topsoils which exceed groundwater limits used for drinking waters.

There are 2.93 million km^2 (69%) of European land where critical loads are exceeded for acidification and 2.65 million km^2 (62%) of semi-natural ecosystems are subjected to nutrient nitrogen deposition leading to eutrophication in 2017 (CIAM IIASA 2018). Critical loads are defined where inputs of a pollutant may impact on ecosystem structure and function. Slootweg et al. (2007) reported that the EU ecosystem land at risk from deposition of some heavy metals such as mercury and lead in 2000 were as high as 51% and 29% respectively.

Lema & Martinez (2017) report 10 million tons of sewage sludge production for EU-27, 37% of the sludge produced in the EU is being utilized in agriculture.

Plastics Europe (2016) reported that 3.3% of total EU plastic demand (49 million tonnes) was used in agriculture. Agriculture produced 5% of plastic waste of EU (EC, 2018).

Organic farming covered 13.4 million hectares of agricultural land in the EU-28 in 2018. This corresponds to 7.5 % of the total utilised agricultural area of the EU-28 (EUROSTAT 2020b). We can assume that pesticides are applied in most of the remaining 92.5% of arable area (21% of EU). This overlap again with (1) and (2).

With respect to contamination of food, the bioavailability of soil contaminants for plant uptake is a complex area as is the pathways of their uptake and the mechanisms by which they can impact on human health (Gregory and Oliver 2015). Due to this complexity, links between contaminants and specific diseases

in individual people needs further study (Hough et al. 2007) as does the impact of mixtures in food of different contaminants on human health (Hernandez et al. 2013). Some specific examples for the EU are available however such as a study of the level of heavy metals in agricultural soils in the EU identified over 6% of soils had levels which could be above those considered adequately safe for food production. The main source of POP exposure in the Czech Republic is through intake of polluted food (Bányiová et al., 2017). A FAO report on soil pollution (Rodriguez-Eugenio et al. 2018) also highlights the potential risk to human health form contaminated soil from unintentional uptake from dust and vapours by farm workers, skin contact, ingestion of contaminants. This can include the risk from pathogens which occur in the soil.

Area of land failing soil health indicator due to soil contamination = 2.5% (non-agricultural) – 21% (conventional arable) – ca. 40-80% of land from atmospheric deposition depending on the pollutant.

7. Soil sealing and net land take

Artificial areas cover 4.2% of the EU (EUROSTAT 2017) of which about 50% is sealed. This would imply that 2.5% of urban land is exposed to pressures (e.g. low inputs, compaction, pollution)

The rate of net land take was estimated to be around 539 km² per year during the period 2012-2018, with (EEA 2019). Between 2000 and 2018, 78 % of land take in the EU-28 affected agricultural areas (EEA 2018). As the rate of recycling of urban land for development is currently only 13% (EEA 2020), this effectively means that every ten years an area the size of Cyprus is paved over (9,300 km2) from agricultural, forestry and conservation land.

Between 2000 and 2006, the average increase in artificial areas in the EU was 3%, however, this masks local issues. Figures exceeding 14% in Cyprus, Ireland and Spain. However, sealing generally consumes high quality agricultural soil, so some overlap with (1) and (2).

Area of land failing soil health indicator due to soil sealing = probably <1% of EU, but can be as high as 2.5%, and can be very important locally.

8. Salinization

The extent of salinization in EU is still uncertain. Ranges estimate 1 to 4 million hectares (enlarged EU), mainly in the Mediterranean and Central European countries (JRC 2008). Taking the higher end of the range means that 0.95% of land is estimated to be affected in the EU. There is an increased risk of salinization due to increased temperatures or decreasing precipitation.

In 2016, 10.2 million hectares was actually irrigated (5.9 % of EU). 25% of this area is at risk of secondary salinization i.e. 1.5% of EU. Spain (15.7 %) and Italy

(32.6 %) had the largest shares of irrigable areas in the agricultural areas of the EU (JRC 2016).

There again will be an overlap with (1) and (2).

Finally, the area at risk of saline intrusions in coastal areas due to sea-level rise is unknown.

Area of land failing soil health indicator due to secondary salinization = 1.5% (greater impact in certain member States)

9. Desertification

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). 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 km2) is deemed highly or very highly susceptible to degradation while large parts of Greece (34%), Bulgaria (29%) and Portugal (28%) are at high risk. There are also concerns for Italy and Romania, where around 10% of their territories are highlighted.

10. Soil biodiversity

It is likely that all of the above drivers are probably singly or in combination resulting in a decline in biodiversity but there are no actual EU data demonstrating soil biodiversity change.

Summary

Based on the convergence of evidence presented in the previous section, **we can conclude that soil degradation is prevalent and extensive in the context of the EU territory**. One could conclude that all soils are under pressure, even if just indirect pressure, from air pollution and climate change.

It seems that 25-30% of our EU soils are currently either losing organic carbon, receiving more nutrients than they need, are eroding or are compacted or suffer secondary salinization, or have some combination. These are all occurring on agricultural land.

An additional 30% of non-agricultural soils are eroding at an unsustainable level.

A minimum of 12.9% of non-agricultural land experiences soil pressures [0.6 (low SOC) + 0.5 (peat) + 7 (compaction) + 2.3 (landfills) + 2.5 (urban)], of which 50% (i.e. 6-7%) is probably not connected with erosion.

Contamination and waste management are probably the biggest unknowns. They include local hotspots (e.g. ex-industrial land, landfills, etc.), widespread air pollution legacy, agricultural land (pesticides, metals, sewage sludge, plastics) as well as unquantified emerging pollutants.

Conclusion

A review of the current evidence of the state of EU soils by the MB and JRC is 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. A 75% goal of healthy or improving soil by 2030 through a radical change in current land management practices is both feasible and necessary. Soils will also benefit from improvement to indirect drivers of change such as reductions in air pollution and carbon emissions.

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Annex 2 Indicators for soil health in support of the mission

Soil health depends on an active and biodiverse vegetation cover that support carbon inputs, supports soil biota and creates good structure, and appropriate management regimes ensuring no compaction or salinisation and protection from contaminants.

Soils, that are low in organic matter for their type, compacted or contaminated by chemicals such as nutrients, heavy metals, remnants of biocides, hormones and drugs at higher concentrations than allowed by health regulations or plant requirements are considered to be unhealthy.

The following indicators are well tested (Bünemann et al. 2018) and used widely at national, regional and global levels (Emmett et al. 2010; Orgiazzi e al. 2018; Moebius-Clune et al. 2018). The list is modest relative to those already in place for water and air quality. If sampled correctly (e.g. not after a fertiliser application) they provide stable indicators for soil health at a given time and of change if repeated at permanent locations. They include two indicators which relate to drivers of change in soil health at the landscape scale:

1. **Presence of soil pollutants, excess nutrients and salts.** When present in higher concentrations than allowed by health regulations or plant requirements: soils are unhealthy. A reduction in levels below recognized threshold values indicates an improvement in soil health.
2. **Soil organic carbon.** Organic matter is important for adsorbing nutrients, retaining water and for improving soil structure and workability of soils as well as plant productivity. Soil organic carbon (SOC) is a major constituent (56%) of soil organic matter and the global soil organic carbon reservoir of soils is two to three times bigger than the carbon as atmospheric CO_2. Therefore, an increase in SOC concentration and stock allows drawing down CO_2 from the atmosphere and an improvement in soil health.
3. **Soil structure including bulk density and the absence of soil sealing and erosion.** Good soil structure as indicated by reduced bulk density, the absence of soil sealing and erosion allows for healthy root growth, reaching all parts of the soil and allowing infiltration of rainwater to prevent runoff and soil loss.
4. **Soil biodiversity.** Presence of functional diversity of appropriate bacteria and fungi and of soil animal communities that are important for soil functions and services, such as soil structure, litter decomposition, organic carbon storage and nutrients cycling promotes all soil functions. Currently, nematodes and earthworms are well tested. Ongoing research will soon deliver indicators for soil microbial parameters.
5. **Soil nutrients and pH.** Essential nutrients for plant growth in part at least, derived from soils include N, P, K, S, Ca. A range of plant micro-nutrients

usually found at very low concentrations (parts per million) in soils may limit plant growth, such as boron (B), chlorine (Cl), cobalt (Co), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn). Soil pH affects many chemical and biological processes, including plant nutrients availability and the balance and functions of soil microbial communities. In farmland and forestry soils, an optimal balance is required for growth. In supporting biodiversity-rich ecosystems, nutrient limitations provide an essential set of sub-optimal conditions to support a diversity of biota above and below-ground.

6. **Vegetation cover.** The annual duration and diversity of the vegetation cover and its net primary productivity is essential for soil health, providing nutrients for soil biodiversity and carbon inputs to soil organic matter, also reducing erosion and surface runoff. A more diverse and long duration cover indicates conditions favourable to soil biodiversity and health and increasing vegetation cover is also valuable for urban settings.
7. **Landscape heterogeneity**, including farmland (field size, fragmentation, presence of natural green elements), forestry (types of forest, monocultures, clear-cuts with bare land) and urban green infrastructures (adequate presence). The diversity of landscape elements (composition) and the way these elements are distributed, including their relative size and their location in relation to the morphology (configuration) strongly influence biodiversity, the water cycle and soil erosion.
8. **Area of forest and other wooded lands**, classified by the number of species, the share of non-native tree species, and the proportion of natural and artificial regeneration. In forests, soil health is influenced by the naturalness in terms of species composition and the management practices, including disturbance by clear cuts.

Note that measurements are soil-specific showing characteristically different ranges of values for different soil types, land uses and climate zones. Methods for capturing information, which can be combined in different ways, include: visual assessments in field; soil sampling with profession laboratory analysis; remote sensing; modelling, crowd sourcing and citizen science. Many methods are already well described but need standardising if time series are to be robust.

How to determine overall soil health of a given soil?

Once indicators have been measured for a given soil they have to be compared with threshold or standard values that separate healthy from unhealthy conditions. Such considerations are land use and climate specific and cannot be generalized. Research will be needed to define such thresholds or standards for each indicator for each soil type set within a land use and climate context using an agreed standard approach.

Methods for their integration to determine if a soil meets or falls below the threshold / standard and thus if a soil can be defined as 'healthy' or ''unhealthy' also requires further testing and a standard method agreed. Different health categories above or below this threshold / standard can also be defined to indicate the relative state of soil health to help inform the urgency and magnitude of action needed. This integration into an overall measure of soil health is critical to be able to monitor the meeting of the mission target for 75% of soils to be healthy or improving by 2030. Different approaches for this integration are already used operationally for other natural resources e.g. the one out/all approach for surface waters in the Water Framework Directive, with various new potential approaches also proposed for soils (e.g. Bonfante et al. 2020). The suitability of options needs to be robustly tested and an approach agreed.

When thresholds for any indicator are exceeded, a soil is below the agreed threshold / standard context specific management actions have to be considered to improve conditions relating to the specific issue(s) which has caused failure. Evidence from experiences obtained at living labs or lighthouses in the area can be helpful here. Continuation of monitoring can then be used to track success of action taken.

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Annex 3 Alignment and support of the mission to EU policies and strategies

This table shows how the mission aligns 'X' or 'Supports' targets of EU policies and strategies.

Targets of different EU policies and strategies	Biodiversity	EU Nature restoration	Farm to Fork	Zero Pollution	Circular Economy	Climate Law	CAP	Mission
30% land protected	X							Supports
Within this, 10% of EU land should be strictly protected (incl. significant areas of carbon-rich ecosystems, such as peatlands, grasslands, wetlands) (BDS)	X						X	Supports
Limited soil sealing and urban sprawl promoting initiatives to reduce soil sealing (CEAP)	X				X			X
Restore degraded ecosystems	X						X	X
25% of EU land organically farmers by 2030	X	X						X
Protect soil fertility, reduce soil erosion and increase soil organic matter	X			X		X	X	X
Identify contaminated soil sites, restore degraded soils; rehabilitate abandoned or contaminated brownfields(CEAP)	X	X			X			X

Improving monitoring of soil quality	X					X	X	X
Soil sealing and contaminated brownfields increase the safe, sustainable and circular use of excavated soils (CEAP)	X	X			X			X
Biodiversity-friendly soil cover	X						X	Supports
Reduction in use of fertilisers by at least 20%; Integrated Nutrient Management Plan to ensuring more sustainable application of nutrients and stimulating the markets for recovered nutrients; **Reviewing directives on and sewage sludge (CEAP).**	X		X					Supports
Degraded and carbon-rich rich ecosystems are restored		X				X		X
Pesticides reduced by 50%		X	X	X				Supports
At least 10% of high diversity landscape features		X						Supports
Urban greening plan		X						Supports
No use of chemical pesticide in sensitive areas		X		X				Supports
EU carbon initiative an certifying carbon removals			X			X		X

Reduce dependency on pesticides and anti-microbials; reduce excess fertilisation and increase organic farming			X	X			X	X
Neutral or positive environmental impact of the food chain			X				X	Supports
Sustainable agricultural practices in hotspots of livestock farming			X					Supports
Recycling of organic waste into renewable fertilisers			X		X			Supports
Dedicated partnership on agro-ecology living laboratories			X					X
Use of AI and satellite technology			X	X				X
The natural sink soils, agricultural lands and wetlands should be maintained and further increased						X	X	X
Continuous progress in enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change						X	X	Supports
Develop and implement adaptation strategies and plans that include comprehensive risk management frameworks, based on robust climate and vulnerability baselines and progress assessments.						X		Supports

Annex 4 Proposed soil relevant indicators for SDG Goals

SDG's	Proposed soil related indicators for SDGs
SDG 1: No Poverty	**Soil health to fight rural poverty** % degraded land in a given country or region
SDG2: Zero Hunger	**Soil health for sustainable agriculture and forestry** % of land area in a given country/region with healthy soils
SDG3: Good health and well-being	**Soil health for healthy and sustainable diets and urban environments** % of land area with contaminated soils % of food supply from a given region that is healthy in terms of nutrient content % of food supply from a given region that is safe in terms of chemical contamination.
SDG4: Quality education	**Soil health for education** % of primary and secondary schools that present environmental courses including the role of soils. % of land managers with Continuing Professional Development
SDG 6: Clean water and sanitation	**Soil health and landscapes for water.** % of land area that has ground- and surface water of good ecological quality % of area where soil conservation practices are implemented
SDG7: Affordable and clean energy	**Soil health supporting sustainable bioenergy production** % of area used for energy crops
SDG11: Sustainable cities and communities	**Soil health for supporting city greening and urban agriculture** % of non-residential areas of cities with healthy soils % of green infrastructure in urban settings
SDG 12: Sustainable production and consumption patterns	**Soil health supporting a circular bioeconomy** Global ecological footprint of soil use and management % of schools with education at an early stage to enable changes in consumption
SDG 13: Climate action	**Soil health for climate change mitigation and adaptation**

	Net mitigation (in tons CO_2eq per km^2) achieved through soil carbon sequestration and associated options in land fit for this purpose. % change in healthy soils by 2050 under current land use and management , as explored by applying simulation models coupled to IPCC scenarios. % of land where greenhouse gas emissions have significantly been reduced
SDG15: Life on Land	**Soils for supporting biodiversity** % land with healthy soils % of land where soils have stable or improving levels of soil biodiversity % of a landscape with vegetation biodiversity % of land protected for nature conservation purposes to protect unusual soil biological assemblages
SDG16: Peace, justice and strong institutions	**Soil health supported by an enabling environment** Better governance through holistic policy making to ensure environmental quality, including soils. Protecting of soils and landscapes that carry our cultural heritage

These soil health indicators should be seen in the context of the existing SDG indicators included by EUROSTAT and also with indicators for drivers of soil health throughout the food chain, from production to consumption. Proposed examples include: % of pre- and postharvest losses of agricultural food and feed production; amount of food waste from production, trade and consumption and sustainable and traceable food and feed chains (for SDG 2) or % of exploitation (recycling) of by-products, wastes, and package materials in a cycling system (for SDG 3).

Annex 5 The mission as a response to the corona pandemic

In their May 9, 2020 issue, the ECONOMIST included a three-page briefing on: *The tables not yet turned",* discussing the major implications of the corona pandemic on food security in the world. Four-fifth of the planet's 8 billion inhabitants are fed in part by imports. The $1.5 trn spent last year on food imports was three times that spent in the 2000's so our reliance on globalisation of the food chain is increasing rapidly. This means that as more countries depend on imports of food, the disruption of the chain caused by coronavirus could trigger a repeat of the food crisis of 2007-2008 that sparked riots from Bangladesh and Burkina Faso to Mauritania and Mexico, and contributed to the conditions that fostered Syria's civil war. Exporting countries are also at risk and will have to rethink the size and form of their food chain.

Independent from the corona crisis, the Mission Board of Soil Health and Food (hereafter call the mission) proposes that these globalised food chains are not only resulting in insecure food supply, as mentioned above, but also by supporting highly industrialized forms of agriculture that may adversely affect environmental- and food quality and, as a result, human health. For example, growing soya for feeding cattle in Europe has resulted in deforestation in the Amazon. In addition, infectious diseases may spread more easily. The mission advocates this situation is reversed with a reduction of the global footprint of European agriculture and, wider application of ecological management procedures for food production where not only production levels are emphasized but also the quality of food, water, air and nature. Soil health and circularity emphasizing local food chains play a key role in such production systems that can be studied in "Lighthouses" and "Living Labs" in close cooperation with land users. A good example is the Market Gardening system where high-quality food is locally produced in a short chain between producer and consumer. Scientific evidence shows that such locally produced food strengthens the immune system making people less susceptible to infections. More sustainable management practices will also protect the soil biome which is a reservoir of future potential therapeutic compounds including new antibiotics and antibiotic-resistance genes. Evidence is also just emerging about additional potential for soil bacteria to be used therapeutically to reduce stress and improve quality of life. Damaging management practices currently contributing to soil degradation has an unknown impact on this untapped potential. Some practices even have the potential to cause direct damage to health of people through increasing risk of pathogen transfers and increasing antimicrobial resistance through the soil matrix into the water and food production system. Soils should be at the heart of rebuilding a sustainable green future.

As described above, the corona crisis demonstrates the vulnerability of the global food system but we have to realize that this all occurs in a condition where worldwide there is enough food being produced. Still, more than 800 million world citizens are hungry but that is due to war, poor distribution systems from farm

to fork or poor governance and corruption. We must also realize that we live a world where up to 30% of food is wasted and where more than a billion people are obese.

When considering the upheaval caused by the corona pandemic in a world of plenty, imagine what may happen if there is no food surplus in future? The MBSHF has emphasized that climate change will most likely have a dramatic effect on the amount of food that can be produced by, say, 2050. Future exploratory climate scenarios by the International Panel for Climate Change (IPCC) show that conditions in many countries may become too dry and hot to allow productive agriculture and may even make human life very difficult, if not impossible. Fresh water is in short supply in many areas of the world, limiting the potential for irrigation. Higher intensity showers may cause more erosion and landslides. Also, the projected sea level rise may flood poorly protected but productive areas of land near seas and rivers. Many of our productive lands are also increasingly covered by roads and buildings, sealing the soil forever and strongly reducing the available area of productive agricultural soils. This needs to be stopped.

Drier and hotter conditions are likely to occur in Southern Europe but also in the Middle East, the Western US and large parts of Asia, South America and Africa, the latter continent having the highest projected population growth. Large areas at high Northern latitudes, like Northern Canada or Siberia may, in theory, become more suitable for agriculture, but soil conditions are generally poor in these areas and there is no agricultural infrastructure. What is left are areas with currently moderate climates. Globally, little research has been done to properly assess the effects of climate change on future agricultural production, emphasizing the role of soils. Pioneering studies by Italian scientists predict alarming drops of productivity of up to 40% by 2070 and this is particularly evident in soils with poor health, due to various degradation processes like compaction, loss of organic matter or pollution. Of course, genetic improvement of crops can help to make crops less sensitive to extreme weather conditions but this will not be adequate to face predicted climate conditions. Market Gardening, ecological farming and vertical farming in city settings may produce significant quantities of vegetables, herbs and fruits in future but this may not be enough and does not cover crops like wheat, rice, sorghum and others that are grown at scale in the field and are the main food staple.

The mission proposes new, operational methods to assess soil health and to apply simulation models for the soil-water-atmosphere-plant system to explore future effects of climate change on crop production. This way, areas can be identified where soils are likely to remain healthy enough and where climate conditions still may allow adequate production levels in future, considering climate change scenarios. And most importantly and urgent: *this should lead to immediate efforts to protect these soils for future generations. The EU can play a leading role here initiating a global effort.*

We now witness the effects of the coronavirus pandemic on food security due to breakdown of the international food chain but this occurs in a world where enough food is produced. One can only imagine "dark scenarios" for a world where not enough food would be available because too many soils cannot produce enough food as a result of climate change and soil degradation. This would most likely lead to the need of massive flows of food from North to South. The Food and Agricultural Organization of the United Nations (FAO) estimates that the 9.7 billion people that will inhabit the earth by 2050 will require a 50% increase in food production compared with current levels. The FAO also shows that more than 25% of our global soils are degraded now and this affects production levels significantly. This can be improved by corrective forms of soil management, as defined by the mission. This will represent a contribution to increase the food production potential. In addition, and more importantly, proposals by the mission to define areas with healthy soils by 2050 and proposals to preserve them are more than ever a crucial contribution to food security in future. The indicators and technology to define such areas are available so there is no excuse for delay. Remember that soils are and always will be the basis for food production. Losing their productive potential by degradation and preserving soils immediately that can still be healthy and productive by 2050, present a deadly recipe for our future world. Soil health and food is more relevant than ever.

Considering the above, the following research priorities can be envisioned to link the mission to future food security and human health by exploring the:

- *soil-health potential of major European soil, including the effects of soil degradation, by considering IPCC climate-change scenarios up to the year 2100*
- *role of major European soils on global food security, considering IPCC climate-change scenarios up to the year 2100*
- *effects of the global food chain on soil- and human health in both importing and exporting countries with the goal to reduce the global EU footprint.*
- *therapeutic potential of the EU soil biome to support the mental and physical health of citizens post Covid and management practices to minimise risk of pathogen and AMR transfer through the soil matrix.*
- *possibility to create a financial intermediary that explicitly concentrates on facilitating the transition to organic and other environmentally friendly farming by supplying or guaranteeing long-term loans.*

Annex 6 Communication and citizen engagement

Communication and citizen engagement are key elements for the success of the mission *Caring for soil is caring for life*, and in general to bring research and innovation closer to societal needs.

Towards a communication strategy and meaningful citizen engagement

The mission board, supported by Commission services prepared a communication strategy intended as a living document and that will serve as a basis for comprehensive actions in this field according to the following goals:

INFORM: raise awareness of the importance of soil health and food and the challenges they faces.

ENTHUSE: use emotive language and strong visual content to convince that we need to act together to achieve the mission

ENGAGE: offer meaningful opportunities for citizens and stakeholders to engage in the co-design/co-creation, co-implementation and co-assessment.

Some of the barriers that the mission should overcome in its implementation to ensure meaningful citizen engagement are: the potential disconnection between development proponents and the local populations; and the inadequate planning and funding (for instance, societal awareness campaigns should be an important component of projects and an adequate budget should be allocated to implement communication and citizen engagement activities).

Tools and materials

The **web presence** of the mission area soil health and food is guaranteed though its webpage. Documents of Mission Board meetings are uploaded in the EC expert group registry.

DG AGRI and DG Research and Innovation social media channels are used for widespread communication of messages and activities with the hastaghs #MissionSoil #EUmissions #HorizonEurope.

At the occasion of the World Soil Day 2019 a video (Soil matter, below), an article (Soil matters for our future, below), a EUSurvey, and the #EIPagriSoil campaign were launched.

Articles

- Soil matters for our future
- Healthy Agricultural Soils: 24 European countries coordinate unprecedented research programme
- Citizen Dialogue in Sofia with Commissioner Gabriel on missions

Videos

- Soil matters
- Horizon Europe Missions
- Salon de l'Agriculture – Plateau télé - AGRI Director Nathalie Sauze Vandevyver and Board member Jean-Francois Soussana

Online material to get involved

- Quiz
- Apple soil game

Events

Members of the Mission Board have promoted the mission area Soil Health and Food at numerous all around Europe (see examples at end of this Annex), reaching more than 1000 people. They also participated in dedicated citizen engagement activities, as highlighted below and published articles for national and international audiences.

Citizen engagement

The Horizon Europe provisional agreement specifies that missions are:

"intended to … have impact on society and policy-making through science and technology; and be relevant for a significant part of the European population and a wide range of European citizens" (Art. 2). They shall "encourage broad engagement and active participation of … citizens and end-users … and … be open to multiple, bottom-up approaches and solutions taking into account human and societal needs and benefits and recognizing the importance of diverse contributions to achieve these missions" (Art. 7.3).

Why is citizen engagement important?

- To inspire society at large, missions need to have widespread **legitimacy and acceptance**
- Balancing top-down and bottom-up perspectives can make **innovation processes richer, better informed, and more likely to be adopted;**
- **Public value** represents not just what citizens demand today, but what they may need or desire in **the future;**
- **Co-design** gives societal ownership of the missions' goals and objectives, ensuring that missions have **longevity;**
- Citizen scientists and innovators can have added value and **complement the implementation of missions;**
- **Co-assessment** can ensure that mission's outcomes are **aligned with the needs, values and expectations of society.**

Examples of citizen engagement events in the co-design phase

- **World Soil Day** – launch of EUSurvey, communication campaign, 5 Dec. 2019
- **Workshop at the COP25** – Madrid, 12 December 2019
- **Mission Café** – Vienna, 16 January 2020
- **International Green Week** – Berlin, 17-26 January 2020
- **Citizen dialogue** – Sofia, 31 January 2020
- **Public hearing at European Parliament**, 18 February 2020
- **Salon de l'Agriculture** – Paris, 22-29 March 2020
- **European Youth Forum** – online event, 10 June 2020
- **Citizen engagement event in Czech Republic** following agreed methodology for all missions – online, 22 June 2020
- **Stakeholder Event (online): Missions in Horizon Europe – Missions Climate, Soil and Cities** – Portugal, 16 June 2020
- **Citizen engagement event in Portugal** following agreed methodology for all missions – online, 09 July 2020
- **A New Mission to Improve Soil Health, Teagasc Research Insights Webinars –** Ireland, 26 August 2020
- **R&I days 2020** –online event, 22-24 September 2020
- **European Week of Regions and Cities: Caring for soil is caring for life – an EU mission to protect healthy soil for food, people, nature and climate** – online event, 22 October 2020

Survey and online platform

Since December 2019 to September 2020 a EU survey available in English, French, German, Polish, Portuguese, and Czech was collecting inputs online, receiving more than 2.500 contributions. In addition, since summer 2020 an **online platform** was developed to keep a constant dialogue with people willing to contribute to the mission.

Other online activities to get involved

Table: Examples of communication and engagement events during the co-creation phase of the mission

Date	Place	Event	Communication and engagement events on mission area Soil Health and Food and the mission Caring for Soil is Caring for Life
25-09-2019	Brussels, Belgium	**R&I days session on "Soil health and food" mission**	Launch of the work of the mission area on Soil Health and Food
19-20-11-2019	Santarem, Portugal	**EIP AGRI focus group on soil contamination**	Presentation and debate with farmers, advisors, scientists
25-11-2019	Brussels, Belgium	**Soil and the SDGs**	Presentation by Mission Board Chair Cees Veerman; debate with science and stakeholders
05-12-2019	Online/global	**World Soil Day**	Citizen engagement: launch of EUSurvey, communication campaign https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme/missions-horizon-europe/soil-health-and-food_en
05-12-2019	Rome, Italy	**Healthy Soil Day**	Italy establishes the National Soil Day - conference with Mission Board Member Catia Bastioli

12-12-2019	Madrid, Spain	**Stakeholder workshop at COP 25 on Horizon workshop missions**	Stakeholder engagement on mission area Soil Health and Food with participation of Mission Board member Carmen Vela
13-12-2019	Santiago de Compostela, Spain	**Fronteras Codigo 100 (event on health innovation)**	Presentation of the mission area by Mission Board member Carmen Vela
15-01-2020	Brussels, Belgium	**Brussels Briefing**	Presentation of the mission area Soil health and food by Mission Board member Emile Frison; target group policy makers, civil society
16-01-2020	Vienna, Austria	**Mission Café**	Stakeholder engagement with participation of Mission Board member Alfred Grand
17-26/01 2020	Berlin, Germany	**Fair: International Green Week**	Citizen engagement at fair with wide audience (incl. awareness raising, games, sounding of views)
27-01-2020	Rome, Italy	**Launch of ReSoil Foundation**	Presentation of the mission area Soil health and food by Mission Board member Catia Bastioli; debate with stakeholders
27-28/01/2020	Katowice, Poland	**International Conference, Towards a green economy, Exchange of experiences of European coal regions**	M. Pogrzeba participated as member of the Mission Board. Panel discussion on soil restoration on postindustrial areas with promotion of the mission area; policy-science debate https://ecosilesia.slaskie.pl/czytaj/to_build_a_green_deal

30-01-2020	Verona, Italy	**Forum on Composting and Anaerobic Digestion at Fieragricola**	Presentation of the mission area Soil health and food by Mission Board member Catia Bastioli; debate with stakeholders
31-01-2020	Sofia, Bulgaria	**Horizon Europe Citizen Dialogue**	Citizen engagement on mission area Soil Health and Food with participation of Mission Board member Lachezar Hristov Filchev
Jan– June 2020	Wageningen, Netherlands	**Student challenge of Wageningen University "Make all soils healthy again"**	Students' engagement initiative with participation of Board Members Johan Bouma and Cees Veerman; see website: www.wur.eu/soilchallenge. https://www.youtube.com/watch?v=FF0bVTauIsE
06-02-2020	Lancaster, United Kingdom	**Soil Policy Event, UKCEH**	Presentation of the mission area Soil health and food by Mission Board member Bridget Emmett; policy and stakeholder engagement event
18-02-2020	Brussels, Belgium	**Public hearing at European Parliament**	Policy discussion with members of the European Parliament
18-02-2020	Budapest, Hungary	**Discussion forum about soils in Hungary**	Presentation of the mission area Soil health and food by Mission Board member Borbala Biro; debate and engagement with farmers

22-29/03 2020	Paris, France	**Salon de l'Agriculture**	Citizen engagement at fair with wide audience (incl. awareness raising, games, sounding of views)
25-02-2020	Paris, France	**Plateau télé at Salon de l'agriculture - A mission for European Soils**	Interview with wide coverage on the mission area Soil health and food by European Commission's DG AGRI Director Nathalie Sauze-Vandevyver and Mission Board member Jean-François Soussana
26-02-2020	Brussels, Belgium	**Final celebratory meeting of FACCE SURPLUS, VLAIO - Flanders Innovation & Entrepreneurship**	Presentation of the mission area Soil health and food by Mission Board member Marta Pogrzeba; debate with stakeholders and programme funders https://ietu.pl/en/miscomar-project-at-the-facce-surplus-final-conference-in-brussels-2/
26-02-2020	Paris, France	**Salon de l'agriculture - official launch of the soil data layer in FR national infrastructure for geographical data**	Presentation of the mission area by Mission Board Member Jean-Francois Soussana; debate engagement with science.
26-02-2020	Budapest, Hungary	**Forum for Hungarian Chamber of Agriculture, Horticulture and Rural Development. Meeting and Discussion**	Presentation of the mission area Soil health and food by Mission Board Member Borbala Biro; debate with farmers

04-06-03-2020	Wageningen, Netherlands	**H2020 CSA CIRCASA project on agricultural soil carbon sequestration**	Presentation of the mission area by Mission Board Chair Cees Veerman; debate with science https://www.circasa-project.eu/About-us/What-is-CIRCASA
01-04-2020	Online event, United Kingdom	**The Royal Society - Soil structure and its benefits**	Presentation of the mission area by Mission Board member Bridget Emmett; debate with science and stakeholders from farming and conservation
06-05-2020	Vilnius, Lithuania	**Info day „Bio-based Industries opportunities in the Horizon 2020 and Horizon Europe" (virtual)**	Presentation of mission area by Mission Board Member Zita Kriauciuniene; debate with industry and science '
07-05-2020	Online event, Italy	**The future of the Italian Wine, quality, sustainability and territory**	Presentation of mission area by Mission Board Member Catia Bastioli; debate with stakeholders from the wine sector (producers and industry)
15-05-2020	Online workshop, Netherlands	**"Mission oriented innovation policies" (on policies)**	Series of workshops organised by the Copernicus Institute of the University of Utrecht with participation of Mission Board member Johan Bouma (45 participants from 14 countries (including Australia, South Korea, Japan)
10-06-2020	Online event, Italy	**Suolo fertile per il Green New Deal italiano**	Policy-science debate to promote the themes of soils and an EU directive on soil health. Mission Board member Catia Bastioli participated at event of the LIFE Project Soil4Life coordinated by the Italian NGO Legambiente and Selena-Istria.

10-06-2020	Online event all over Europe	**European Youth Forum**	Citizen engagement with students and young professionals; participation of Mission Board member Alfred Grand
14-06-2020	Online event, Italy	**"La risorsa sotto i piedi: ripartiamo dalla valorizzazione del suolo". (the resource under our feet: restart from the valorisation of soil)**	Live streaming with a focus on climate/ environment and soils with participation of Mission Board member Catia Bastioli; industry – science – citizens audience
16-06-2020	Online event, Portugal	**Missions in Horizon Europe – Missions Climate, Soil and Cities**	Stakeholder Event with participation of Mission Board member Teresa Pinto Correia
22-06-2020	Online event, Czech Republic	**Citizen engagement: Horizon Europe mission area Soil Health and Food**	Citizen engagement event following agreed methodology for all missions with participation of Mission Board member Emil Cienciala
09-07-2020	Online event, Portugal	**Citizen engagement: Horizon Europe mission area Soil Health and Food**	Citizen engagement event following agreed methodology for all missions with participation of Mission Board member Teresa Pinto Correia

10-07-2020	Online event, Italy	**Meeting of Strategic Partners of the University of Gastronomic Science of Pollenzo (Carlin Petrini)**	Dialogue with the gastronomic sector with participation of Mission Board member Catia Bastioli. Special video recording by Carlo Petrini, Founder of Slow Food for mission Caring for Soil is Caring for Life (possible adaptation of the movie for other engagement actions)
27-07-2020	Online event, Spain	**Engagement event on mission area Soil Health and Food**	Engagement event with stakeholders from practice and academia with participation of Mission Board member Carmen Vela
20-07-2020	Online event, Italy	**Presentation of the 2020 report of ISPRA-SNPA: "Consumption of soil, territorial dynamics and ecosystemic services"**	Presentation of proposed mission by Mission Board member Catia Bastioli; dialogue with science
26-08-2020	Online event, Ireland	**A New Mission to Improve Soil Health,**	Teagasc Research Insights Webinars with participation of Mission Board member Jean-François Soussana
08-09-2020	Vienna, Austria	**27th Conference of the Working Group Sustainability of the Danube Regions**	Presentation and debate on mission with regional stakeholders from the Danube region and international partners: regional, national authorities, farming and food sectors, science. Participation of Mission Board Chair Cees Veerman
16-09-2020	Online	**Kick off meeting of EJP Soil**	Presentation of proposed mission by Mission Board member Borbala Biro; debate with science and programme funders

18-09-2020	Online workshop, Netherlands	**Mission oriented innovation policies (on coordination)**	Series of workshops organised by the Copernicus Institute of the University of Utrecht, were Johan Bouma actively participated. 45 participants from 14 countries (including Australia, South Korea, Japan) took part in the meeting.
22-09-2020	Online event, Poland	**Polish National Soil Platform Scientific conference "Integration and improvement of Polish soil classification systems - agricultural, forest and anthropogenic soils"**	Presentation of proposed mission by Mission Board member Marta Pogrzeba; scientific debate http://www.iung.pulawy.pl/index.php?option=com_content&view=article&id=2512:konferencja-integracja-i-doskonalenie-systemow-klasyfikacji-gleb-polski-gleby-rolnicze-lene-i-antropogeniczne&catid=36:konferencje
24-26/09 2020	Online event, Lithuania	**Virtual exhibition ”Inno Panorama 2020”**	Exhibition and seminar with participation from Mission Board members Zita Kriauciuniene and Alfred Grand
Planned: 05-10-2020	Online event (tbc)	**Stakeholder event on mission Caring for Soil is Caring for Life**	National stakeholder debate with participation by Mission Board Member Bridget Emmett

Planned: 22-10-2020	Online event	**European Week of Regions and Cities: Caring for soil is caring for life – an EU mission to protect healthy soil for food, people, nature and climate**	Engagement event with broad range of stakeholders including representatives from local and regional government

Annex 7 Potential mission support from EU and national programmes and initiatives

Mission objectives and building blocks	Targets by 2030 and ambitions under mission building blocks	Links with EU and global policies, strategies and objectives (selected examples[8])	Synergies and potential support from EU Programmes and Instruments (selected examples)

Objective 1: *Reduce land degradation, including desertification and salinization*
 	
Objective 2: *Conserve and increase soil organic carbon stocks*
 	
Objective 3: *No net soil sealing; increase the re-use of urban*
	• **T1.1**: 50% of degraded land is restored
	• **T2.1**: Current carbon concentration losses on cultivated land (0.5% per year) are reversed to an increase by 0.1-0.4% per year
	• **T2.2**: The area of peatlands losing carbon is reduced by 30-50%
	• **T3.1**: The current rate of soil re-use is increased from current 13% to 50%
		• Sustainable Development Goals (SDGs)
		• European Green Deal
		  ○ Farm to Fork
		  ○ Biodiversity strategy
		  ○ EU Adaptation strategy (under preparation)
		  ○ Zero Pollution Action Plan (under preparation)
		  ○ EU Climate Law
		  ○ EU Climate Pact
		  ○ EU Circular Economy Action Plan
			• CAP (including CAP new payment schemes) and CAP Strategic Plans
			• The European Innovation Partnership Agriculture (EIP AGRI)
			• CAP networks
			• NextGenerationEU, including Recovery and Resilience Facility
			• European Regional Development Fund and Cohesion Fund (including Interreg programme)
			• European Social Fund

[8] Based on currently available information, September 2020. Many programmes and initiatives are still under negotiation and/or subject to agreement on the 2021-2027 Multiannual Financial Framework.

soils for urban development **Objective 4**: *Reduce soil pollution and enhance restoration* **Objective 5**: *Prevent erosion. with unsustainable erosion rates* **Objective 6**: *Improve soil structure to enhance habitat quality for soil biota and crops* **Objective 7**: *Reduce the EU global footprint on soils* **Objective 8**: *Increase soil literacy in*	• **T4.1**: At least 25% area of EU farmland under organic agriculture • **T4.2**: A further 5-25% of land with reduced risk from eutrophication, pesticides, anti-microbials and other contaminants • **T4.3**: A doubling of the rate of restoration of polluted sites. • **T5.1**: Stop erosion on 30-50% of land with unsustainable erosion rates. • **T6.1**: Soils with high-density subsoils are reduced by 30 to 50%. • **T7.1**: The impact of EU's food and biomass imports on land degradation are reduced by 20-40%. • **T8.1:** soil health is firmly embedded in schools and educational curricula. • **T8.2:** uptake of soil health training by land managers is increased.	○ EU Forest strategy (under preparation) • Common Agriculture Policy (CAP) • EU Nature Restoration • Updated Bioeconomy Strategy • EU-Africa Strategy • Smart and Sustainable Mobility Strategy 2020 • Urban Mobility Initiative – for 2021 • Soil Thematic Strategy (ongoing update) • Global Soil partnership • Global research alliance on agricultural greenhouse gases	• LIFE programme • EU Digital Package, the Digital Europe Programme and digital experimentation facilities • Connecting Europe Facility • EU Soil Observatory • Copernicus programme • Horizon 2020: Art. 185 PRIMA • Horizon Europe - all pillars incl. planned missions (on Climate Adaptation, Oceans, Cities and Cancer) and partnerships on: ▪ Biodiversity ▪ Agro-ecology ▪ Sustainable food systems ▪ Water for all

society across Member States	• **T8.3:** understanding of impact of consumer choices on soil health is increased.		
Building Block 1: *Ambitious R&I Programme*	Deliver research results, innovation and knowledge	• Cross-cutting objective on innovation, knowledge exchange and digitalisation of the CAP • Support to building of European Research Area • European Education Area • Soil Atlas of Europe	• All parts of Horizon Europe • National R&I programmes • Erasmus+ Programme • European Universities Initiative • "Researchers at Schools" initiative • European Institute of Innovation and Technology (EIT) • European Innovation Council • Creative Europe Programme
Building Block 2: *Co-creation and sharing in Living Laboratories and Lighthouses*	In the first years of the Mission at least five, preferably 10 living labs and/or lighthouses in each of the regions of the EU. This will result in 1000 – 2000 living labs and lighthouses as incubators and demonstrators of change.	• International and European strategies and approaches to Living Labs	• Horizon Europe • Agro-ecology partnership: living labs and research infrastructure • CAP (including CAP new payment schemes) and CAP Strategic Plans

			• EIP-AGRI (European Innovation Partnership of agricultural productivity and sustainability) • EIT Climate-KIC Deep Demonstration programmes • Food Deep Demonstration programme • European Experiential Learning Lab on Soil Science –Erasmus cooperation project and platform • NextGenerationEU, including Recovery and Resilience Facility • LIFE programme • Interreg programme • Erasmus+ Programme
Building Block 3: *Soil monitoring programme*	• Improved ways for monitoring the status of soils • A robust soil monitoring programme in each MS following established indicators	• Biodiversity Strategy • Farm-to-Fork Strategy • Integrated Nutrient Management Action Plan (2022) • Commission proposal for Regulation on support for CAP Strategic Plans (2018)	• Horizon Europe • JRC, EU Soil Observatory as a repository of mission outcomes and of LUCAS soil • LIFE programme • European Space Agency (ESA) for Society • Copernicus programme

		• Soil Thematic Strategy update (ongoing process)	• National monitoring programmes • JRC Support Programmes
Building Block 4: *Communication and citizen engagement*	• Raising citizens and land managers awareness to the need for a transformative change in land use practices • Support consumers to understand and valorise healthy soils services	• EU communication and citizen engagement strategies • National communication and citizens engagement strategies • Citizen driven innovation strategies	• EU and national/NGO communication and citizen engagement campaigns • World soil day campaign • EU citizens' dialogue • National education curricula • EU Researchers at Schools" initiative • Communication and awareness raising activities of the EIP-AGRI Network • EIP-AGRI Focus Groups • EIP-AGRI workshops and seminars, networking events • The Creative Europe Programme • The European Solidary Corps

Annex 8 A Manifesto for citizens

Mission: Caring for soil is caring for life - ensure 75% of soils are healthy by 2030 for food, people, nature and climate

Why are healthy soils important?

Soils forms the skin of the earth and are essential for all life-sustaining processes on our planet. If soils are healthy and are managed sustainably, they provide many benefits to people, nature and climate. Healthy soils are essential in delivering healthy food and other essential ecosystem services to humankind, such as the production of biomass, the purification of percolating water and avoiding surface water pollution, reducing greenhouse gas emissions, carbon capture for climate mitigation and last but not least preservation of biodiversity.

But soil health is threatened all over Europe and globally. Mostly through chemical pollution, biocide residues, plastics or excess tillage and loss of organic matter. This can strongly affect the level of food production and its quality. Moreover, climate change exacerbates these threats. Scenarios for the EU indicate an increasing vulnerability of the soil's natural capital to desertification throughout this century. Even though there is enough food at present, globally climate change may result in structural shortages by 2050 as many areas become too hot and dry for plant growth while fertile soils along rivers and seas may flood due to sea level rise.

In the EU, soil sealing, loss of soil organic carbon and biodiversity, compaction, erosion by both water and wind, salinization and soil contamination lead to annual costs that may exceed[9] 50 billion €. So preserving and restoring soil health is a pressing need even for the near future. The EU has committed itself to preserve soils and its manifold ecosystems services, amongst others by accepting the United Nations Sustainable Development Goals and recently the EU Green Deal.

In view of these facts, the Mission on Soil, Health and Food is timely, logical and essential.

Five underlying principles have guided the efforts of the members of the Mission Board "Soil, Health and Food":

1. Missions should be instrumental to the Green Deal and the Sustainable Development Goals. That means that scientific projects and applications will be assessed against their practical contributions to solutions for societal needs and problems and to new approaches to reach the Mission Goals.

[9] Costs were estimated at €38 billion annually for 25 EU countries (*The Implementation of the Soil Thematic Strategy and Ongoing Activities* EC, 2012) but this figure did not include costs from biodiversity decline, sealing or compaction.

2. Soil should not be considered solely from an economic point of view as a usable stock of wealth that can be exploited (like a mine or a well). Soils are a complex organism that act as a fund that continuously delivers ecosystem services. Therefore, soil should be preserved and taken care of. Soil also has a value in itself, with its use subject to ethical standards that yield for every living organism.
3. Scientific contributions and technical solutions alone will not be sufficient to realize the 'Great Transformation' as is incorporated in the Green Deal. Changes in existing support systems and soil management, dissemination of objective information and monitoring of outcomes are indispensable elements to support the necessary restoration of soil health for people and planet as a whole.
4. Interdisciplinary scientific methods based on a system approach - firmly embedding human and social sciences - are of vital importance in developing a broad holistic view in order to prevent 'path dependent' solutions and facilitate a break trough of new ideas and unusual but effective implementations.
5. Citizen engagement is vital not only for acceptance but to ensure ownership of citizens for measures to be taken, to stimulate a change in the mindset of consumers and producers, and also to tap and create new ideas, from 'the wisdom of the crowd'. This should be organized and facilitated in a bottom-up manner and not top-down. It is crucial to let the movements of change gradually grow as a true and strong performance of civil society to secure a sustainable future by itself and for itself and future generations.

The Mission Board Soil, Health and Food proposes to engage into a process of change to realize the following ambitions about making soils healthy again.

The main goal of mission Caring for soil is caring for life: By 2030, at least 75% of soils in each EU Member States are healthy, or show a significant improvement towards meeting acceptable thresholds, to support ecosystem services[10].

This goal corresponds to a 100% increase in healthy soils. In line with the above goal, the following **objectives and targets** will be achieved **by 2030**[11]**:**

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[10] "By ecosystem services we mean the services provided and the benefits people derive from these services, both at the ecosystem and at the landscape scale, including public goods related to the wider ecosystem functioning and society well-being" (Haines-Young and Potschin 2018; MA 2005)

[11] Goal, objectives and targets are at the EU scale and feasible. However, they will require a large transformation that will not be easy to trigger across all EU regions in the given timeframe.

Objective 1: **Reduce land degradation,** including desertification and salinization.

Target 1.1: 50% of **degraded land is restored** moving beyond land degradation neutrality.

Objective 2: Conserve (e.g. in forests, permanent pastures, wetlands) and increase **soil organic carbon stocks.**

Target 2.1: current **carbon concentration** losses on cultivated land (0.5% per year) are reversed to an increase by 0.1-0.4% per year;

Target 2.2: the area of managed **peatlands** losing carbon is reduced by 30-50%.

Objective 3: **No net soil sealing** and increase the **re-use of urban soils** for urban development.

Target 3.1: switch from 2.4% to **no net soil sealing;**

Target 3.2: the current rate of **soil re-use** is increased from current 13% to 50% to help meet the EU target of **no net land take** by 2050.

Objective 4: **Reduce soil pollution and enhance restoration**

Target 4.1: at least 25% area of EU farmland under **organic agriculture;**

Target 4.2: a further 5-25% of land with reduced risk from **eutrophication, pesticides, anti-microbials** and other agrochemicals and contaminants;

Target 4.3: a doubling of the rate of **restoration** of polluted sites.

Objective 5: **Prevent erosion**

Target 5.1: **stop erosion** on 30-50% of land with unsustainable erosion rates.

Objective 6: Improve **soil structure** to enhance habitat quality for soil biota and crops.

Target 6.1: soils with high-density subsoils are reduced by 30 to 50%.

Objective 7: Reduce the **EU global footprint on soils.**

Target 7.1: the **impact of EU's food, timber and biomass imports** on land degradation are reduced by 20-40 %.

Objective 8: Increase **soil literacy in society across Member States.**

Target 8.1: soil health is firmly **embedded in schools** and educational curricula;

Target 8.2: uptake of **soil health training** by land managers and advisors is increased;

Target 8.3: understanding of **impact of consumer choices** on soil health is increased.

How can we support soil health through research and innovation? The Board strongly advises the following approaches:

Much expertise in the area of Soil Health and Food is already available after many years of research and experiences obtained in practice. The limitations of approaches that focus primarily on production and consumption from an economic point of view have increasingly become evident in terms of negative environmental side effects on water, nature and biodiversity. To face the formidable challenges ahead of us on soil, health and food (as for instance mentioned in UN Sustainable Development Goals and the Green Deal) we propose a paradigm shift, a fundamental change in the way we approach the problems the Mission is about. This implies, in summary, that:

(i) rather than being considered as a stock to be exploited, soils are considered as a precious living organism and an indispensable resource to be cared for; (ii) soils not only produce marketable products as food, fibers, etc., but also public goods, like beauty of the landscapes, biodiversity, or recreation services. These values without a market price deserve more emphasis; (iii) the highly adaptive character of land use is acknowledged by engaging experienced practitioners in a joint learning approach with researchers; (iv) emphasis is placed on inter- and transdisciplinary research with a strong social component; (v) system approaches should replace reductionist, traditional approaches; (vi) in order to facilitate changes in behavior of land managers and owners, mandatory prescriptive environmental rules and regulations leading to passive management behavior and exploration of loopholes should be reconsidered. The stimulus should be to challenge actors in the field by defining clear targets and indicators and time frames intended to be reached. These should be formulated in interaction with land users and based on a system of bonus/malus accountability.

In more detail, the following statements elaborate on our recommendations and specifically illustrate areas where new approaches are proposed.

How can the ambitions of the Mission be made more concrete and be quantified?

We propose **seven focal areas** of necessary innovation**:**

1. **Change the traditional more static soil paradigm to: Living soils form the vulnerable skin of the earth, contributing to essential ecosystem services for mankind**

We emphasize the role of soil health in terms of contributing to ecosystem services that, in turn, contribute to SDGs and the Green Deal.

Live on earth is governed by nature and by the ecosystem services provided by soils. Modern agriculture and forestry should not be focused only on the ecosystem service biomass production, but should satisfy the other ecosystem demands as well. Different scientific disciplines have to combine forces to assess and improve such services at different spatial levels and realizing soil health is the best contribution that the soil science discipline can make. Though important, soils cannot by themselves determine the quality of ecosystem services. Interdisciplinary research approaches are therefore essential, where soil scientists are active members of interdisciplinary teams. We advocate a systems analysis of the entire production system by contributing soil data to and applying available soil-water-atmosphere-plant simulation models that are already widely used in agronomy, hydrology, climatology and ecology. We define ecosystem services as a bundle of performances that support, facilitate and secure all life on our planet. Soil health we define along this line as: **The continued capacity of a certain type of soil to contribute in providing ecosystem services for all forms of life, in accordance with the goals of the SDGs and the Green Deal.**

For many years soils have clinically been considered as porous media conducting water and adsorbing and releasing nutrients. But soils, unseen below the surface of the earth and therefore unknown to many, are biologically active parts of dynamic landscapes supporting life in many forms. Soil use is subject to ethical standards that apply to every living organism. These ideas are not new, but need increased emphasis and articulation in times of major environmental challenges. We advocate emphasis on studying the soil biome and applying modern communication techniques that will offer new, unexplored opportunities for effective communication and engagement.

2. **Advocate for a model that starts with an interactive, joint-learning approach by stakeholders and researchers focusing on "lighthouses" and "Living Labs" as seeds for replication**

Much research is available on numerous aspects of land use systems. But too often such research is not implemented because of socio-economic reasons or because of the complexity of real-world adaptive management. We therefore suggest to turn the traditional research-chain around and start with identifying innovative and successful case studies of circular value chains for soil regeneration that can act as "lighthouses" ('showcases') of what is developed and successfully in practice. Many examples do exist at this point in time! They are an opportunity to experiment how to produce more with less: a key future societal

challenge. Another instrument are ”living Labs” (or try outs) endeavours on field experiments. This joint-learning approach of all stakeholders, best practices need to be documented and disseminated since they can act as ”seeds” to accelerate their scale-up and replication through adaptation to the specific local contexts.

The concepts of ”Lighthouses” and ”Living Labs” are not new but our explicit recommendation above, applying sets of modern sensing and monitoring methods will deliver the quantitative documentation of ecosystem services as concrete results. These will be essential to improve communication and engagement with other land users, the public at large and the political arena.

In order to support land users in their transition towards more sustainable land use and making soils healthier, it is recommended that a financial mechanism is in place providing farmers and other land managers with access to long term loans.

3. We present operational targets and indicators for soil health

We define, in contrast to the state-of-the-art, a simple set of indicators for soil health and also indicators for a series of ecosystem services mentioned under point 1.

So far, targets and indicators for the SDG’s - as a point of reference and that is largely adopted by EUROSTAT and the Green Deal – do not mention soils and soil health. We therefore propose eight soil-related indicators including two at the landscape scale (Annex 2). We also propose twenty three indicators which link the mission with the SDG targets (in accordance with eleven SDG’s, Annex 4) and provide convincing reasons why soil health is important in this context. We also define operational procedures to quantify the various indicators.

4. We suggest to define new research by filling gaps in knowledge perceived when applying existing expertise

Much useful data and information on soils and their functioning has been accumulated in more than hundred years of research. The urgency to face up to the enormous challenges implies that no time can be lost. When studying soil contributions to ecosystem services, existing expertise and methodology should be applied first before new research is initiated. The latter should be focused on filling gaps in knowledge appearing when applying existing expertise. ”Curiosity driven” interdisciplinary research is needed to fill such gaps.

5. We advise to better link food quality and safety to chemical and biological soil conditions and processes

A large body of literature has been published on the relation between food quality and human health. However, much less is known about the relation between food quality and soil health. It is important to identify suitable and unsuitable soils for growing various crops or vegetables and to define critical thresholds of chemical pollutants in soil, such as heavy metals, remnants of pesticides, medicines, drugs

and plastics. Soils are not only the positive source of new antibiotics but also a negative source of organisms that threaten human health. Their occurrence and development in different types of soil is still largely unknown and needs more attention. And also pay much more attention to the effects of methods of conservation, packaging, storage and transportation in the food chain, in relation to soil health in order to prevent ongoing contamination and waste.

6. We propose to apply systems analysis to explore whether there will be enough healthy soils in the world by 2050

Currently, there is enough food in the world. Widespread hunger is largely the result of war, poor distribution or inappropriate governance. But what will be conditions in 2050 as many soils will become too dry and hot while fertile areas near rivers and seas may flood due to climate change and sea level rise? How to feed 10 billion demanding people by 2050? This question remains unanswered at this time. An exploratory cross-sectorial systems analysis, applying soil-water-atmosphere-plant simulation models, can indicate which soils are likely to be still healthy in 2050.

7. Ensure the EU global soil footprint is reduced

Any action in the EU has a positive or negative impact in non-EU countries due to complex supply chains. We must avoid outcomes which could imply exporting our problems associated with poor soil health or importing products produced on unhealthy soils. This observation is particularly relevant in the current health crisis where international food supply chains are being challenged.

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Caring for Soil is Caring for Life" is the title of the mission proposed by the Soil Health and Food Mission Board.

The mission's goal is to "ensure that 75% of soils are healthy or improving by 2030 and are better able to provide essential ecosystem services", such as the provision of food and other biomass, supporting biodiversity, storing and regulating the flow of water, or mitigating the effects of climate change. The target corresponds to a 100% increase of healthy soils against the current baseline.

This interim report sets out the vision and the blueprint to reach this ambition through a combination of research and innovation, training and advice, as well as the demonstration of good practices for soil management using "Living labs" and "Lighthouses". To be successful, the mission will also improve the monitoring of soil health and the pressures acting on them, mobilise investments, and encourage changes in policies.

The mission will be a joint endeavour by stakeholders, researchers, policy-makers and citizens alike that will put Europe on a path towards sustainable land and soil management as part of a wider, green societal transition.

Studies and reports

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