

Policy instruments for soil protection among the EU member states: A comparative analysis

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Many factors threaten European Soils, and currently, all the Member States (MS) are introducing many types of soil protection measures. Erosion, pollution, sealing and decline of the organic matter are just some of the threats that affect one of the primary non-removable resources of the planet. Soils play a vital role in the biodiversity and are the provider of numerous Ecosystem Services that support human life on Earth.

Following the withdrawal of the Soil Framework Directive proposal by the European Commission, we investigate how the different MS of the European Union (EU) address sustainable soil management under the pressures of different threats.

The methodology used is based on a gap analysis applied to the instruments and/or policies adopted by the MS to contrast the various threats according to their specific level of intensity. The study presents for the first time a systematic review of the current EU policies covering all the regulatory instruments, the economic instruments, the information tools, the monitoring systems, and the research and innovation activities.

The comparative analysis of the different approaches adopted by MS reveals the absence of a common EU strategy to address soil protection and the inefficacy of the subsidiary principle in the sustainable management of soil resources especially in the view of addressing the Sustainable Development Goals achieving the targets by 2030.

Results show how the lack of a Soil Framework Directive has weakened the possibility to have strong co-ordination among the MS for soil protection. Each Country is adopting an autonomous legislative framework which reveals a huge dis-homogeneity and un-coherences among approaches.

Keywords:

Soil regulation

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Legal framework

Land use policy

Gap analysis

Sustainable Development

Goals

1. Introduction

Soils are major providers of crucial Ecosystem Services (ES) since they contain one-quarter to one-third of all living organisms on the planet. Only around 1% of all soil microorganisms have been classified, compared to 80% of plants (Jeffery et al., 2010). Soil organisms contribute to a wide range of services essential to the sustainable functioning of all ecosystems (also called soil functions) (Blum, 2005; Commission of The European Communities, 1990); they act as the primary driving agents for nutrient cycling, water purification, regulating the dynamics of soil organic matter and structure, soil carbon sequestration and greenhouse gas emissions (Breure et al., 2012). Moreover, soils are the foundation of all terrestrial ecosystems and the agricultural and forestry provisioning services, as well as the structural medium for supporting the Earth's biosphere, regulating the ecosystem

functions for human's health.

Soils are commonly considered as a non-renewable resource, due to their extremely slow rate of formation and their resilience, when subject to some form of degradation. The regeneration process of soil is complex. It occurs rarely and requires a considerable amount of time and energy: For example, to restore degraded soil to its original condition takes ca. 500 years to gain just 2.5 cm of surface crust (Pimentel et al., 2010). Soil degradation is defined as the loss of its quality and the intrinsic characteristics which are necessary to provide specific functions (Blum, 2008). The process of degradation is considered a threat which can be caused by external natural events, such as storms or hurricanes, that can have an impact on the stability of the soil leading to landslides or flooding; or as a result of anthropogenic activities such as intensive and unsustainable agriculture that alters the levels of nutrients and pollution in the soil. Normally, anthropogenic processes are

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the main causes of soil degradation (Blum, 2002). Nevertheless, such alterations are often indirectly caused by climate change, such as intense rainfall events, which lead to erosion, landslides or flooding, also considered as anthropogenic processes.

Despite awareness of the human pressures on European (EU) soils and the related negative consequences to the environment and human well-being, there is currently no common EU legislation on soil protection. In recent years, various attempts have been initiated at EU level on the subject of soil protection, starting with the EU Communication COM (2002)179 "Towards a Thematic Strategy for Soil Protection" which identified the different soil threats relevant to the EU area, such as erosion, decline in organic matter, contamination, sealing, compaction, loss of biodiversity, salinization and floods and landslides. The last two threats were subsequently addressed by a specific Directive on flood risk management prevention (2007/60/EC) and therefore not included in the final EU soil strategy.

The proposal of a Soil Framework Directive, as a legally binding component of the EU Soil Thematic Strategy, was endorsed by the EU Parliament in 2007 but blocked by a minority of Member States (MS) (Germany, France, The Netherlands, the United Kingdom and Austria) and therefore not adopted.

The reasons for the opposition include the subsidiarity and proportionality principles, the estimated costs, the administrative burden, and existing national legislation on soil that which was not considered as aligned with the incoming proposal (Glæsner et al., 2014).

In 2014, the European Commission (EC) decided to withdraw its legislative proposal and looked at an alternative strategy which aimed at a better integration of soil degradation issues into existing and forthcoming EU legislation. The Commission remains committed to the objective of soil protection, and will examine options as to how best to achieve this (European Commission, 2014). Various studies and technical reports keep stressing that around 10–20% of drylands and 24% of productive lands are degraded on a global scale (ELD Initiative, 2013). "This situation suggests that all efforts made to integrate soils in various EU policies and through national legislations are still insufficient to reduce soil degradation. It calls for a common reflection which we would like to engage with MS" (European Commission, 2015).

In addition to this formal evidence, the soil issue gained popularity due to the International Year of Soils 2015 and by the promotional role of the Food and Agriculture Organization of the United Nations (FAO) in hosting the Global Soil Partnership (GSP). The FAO has acted in the recent years through publications, the promotion of Policies and Governance, the dissemination of scientific results and the organization of awareness raising initiatives on Soil, with an online campaign of bulletins and reports uploaded on the FAO Soils Portal (FAO - Food And Agriculture Organization of the United Nations, 2013). Soil has also been at the centre of academic and scientific debates involving local communities, promoting citizen's initiatives and requesting an EU legislative framework for protection and management. Of particular importance has been the debate around the importance of soils in the achievement of the Sustainable Development Goals (SDG) in 2030 (Keesstra et al., 2016). These are to be achieved by fully implementing sustainable soil management as recommended by FAO in the World Soil Charter (FAO, 2015) and following the Voluntary Guidelines for Sustainable Soil Management (FAO, 2016). The requirement for soil legislation promoting sustainable soil management is still one of the topics under discussion among policymakers at different government levels and needs to deliver binding legislation on soil protection.

There has recently also been a proliferation of research projects, studies and initiatives focused on the importance of soil. The aim has been to spread awareness on the importance of soil and on the effects of its depletion and degradation caused by mismanagement, including the role it plays in the provision of ES for nature protection and human well-being (e.g., Recare - preventing and remediating degradation of Soils in Europe through Land Care, LANDMARK2020, SOILCARE -Soilcare for profitable and sustainable crop production in Europe and

MAES - Mapping and Assessment of Ecosystems and their Services). These projects have strongly encouraged the assessment of soil functions across the EU introducing decision-support tools, new policy frameworks and sustainable management of soils and land use.

Even if soil's value is increasingly recognized, there is no common EU agreement on the best practices to adopt for tackling soil threats and improving ES provision. The lack of a common EU framework has motivated MS to act independently, adopting and implementing sectoral policies and strategies.

This paper aims to investigate how the different EU MS address the threats posed to soil in the absence of an EU Soil Framework Directive. The data and the considerations that follow are based on documental research of available information at EU and MS level through a "Gap analysis". The Gap analysis focuses on the instruments and/or policies adopted by MS, according to the severity of soil threats that affect soil functions and quality. The results of this analysis are presented for each MS, providing a summary of the adopted measures to limit the effects of the threats according to their level of severity. The measures concern the regulatory instruments, economic instruments, information tools, monitoring systems and research and innovation activities. They are subsequently divided into sub-categories, highlighting the existence of some legislative gaps that could be considered in future policy initiatives. The analysis outlines the comparative approaches adopted by MS and aims to shed lights on the limits of an uncoordinated approach taken by EU MS to address soil protection and the efficacy of the principle of subsidiarity in the management of soils.

2. Materials and methods

2.1. Assessment of the European Union soil threats

The analysis is based on the data and information collected by the existing collaborative web platform (Soil Wiki), which was employed by the EC to set out a first report entitled "European Inventory and Assessment of Soil Protection Policy Instruments in the European MS". This led to a second communication on the "Updated Inventory and Assessment of Soil Protection Policy Instruments in European MS", edited in February 2017 by the Ecologic Institute (Berlin) in collaboration with the Institute for European Environmental Policy, Milieu (Law and policy consulting), BEF Latvia, University of Copenhagen and the Center of Ecological Engineering, funded by the European Commission, DG Environment (ENV. B.1/SER/2015/0022) (Frelil-Larsen et al., 2017).

The web platform was created in 2006 to collect existing and future soil protection policies and measures at EU and MS level. The structure of Soil Wiki was defined by the study team and national Member State experts on Soil as a collaborative website to be completed by each MS (input data was the same for all MS, and the initial dataset was used to share a list of the major threats to be included in the repository) (Frelil-Larsen et al., 2017).

Since 2016, Soil wiki has collected data on policies that have an explicit or implicit reference to soil threats or soil functions. It is the result of a process of data homogenization that allows a comparison of the policy instruments from different MS and the approach of each MS to Soil protection.

After the homogenization of data and information, a testing period was launched to define the final policy instruments page, where MS screened their legislative texts to fill in the sources of knowledge for Soil Wiki. In the middle of 2016, Soil Wiki was established by the working team, and, afterwards, a review process by MS experts started to check its contents. This process enabled a revision of incorrect or incoherent information while adding additional policy instruments whenever they were not mentioned on the initial Soil Wiki page. The project included the interaction between the soil protection expert group and the European Commission, resulting in a preliminary as-sessment of both EU level policies and national or regional soil policies

initiatives. Soil Wiki collected 35 EU level policies and 671 instruments across the 28 EU MS (Freluh-Larsen et al., 2017).

As stated by Freluh-Larsen et al. (2017), Soil Wiki does not incorporate regional activity, therefore it not possible to gain an overall picture of the different approaches to soil protection in the different regions. The platform has become a collaborative database of policies used for the Gap Analysis, emphasizing shortcomings in soil protection at MS level focusing especially on areas where protection weaknesses persist. The final part of the paper is devoted to the Gap Analysis summary and discussion, fostering the debate around future policy initiatives and the need for a coordinated system of rules for soil protection, including also the possibility of reconsidering a "Soil Framework Directive".

The need for an assessment of current pressures (threats) and responses (policy instruments) on soil is currently a key issue in the consideration of further policies at EU level. In conclusion, a two-steps analysis has been conducted. In the analysis, an initial individual policy assessment was set out to understand i) the coverage and management of the policy (including its explicit or implicit relation to a soil function) and ii) the strengths, weaknesses, opportunities and threats (SWOT) relating to soil protection. The second step consisted of a clustered assessment of the coverage of soil threats and functions.

Distinctions were also between binding (such as regulations, ordinances, decrees) or non-binding measures (monitoring, funding, voluntary agreement, research and innovation projects, and awareness-raising schemes). The coherence between MS national instruments and EU legislation was evaluated as an alignment between EU level policies and national ones. Complementary policies are addressed where MS have included in the inventory the gaps in EU policies. Final considerations were devoted to a consideration of how the MS policies are determined by gaps at EU level and vice-versa.

2.2. Soil threats in the European Union

The Gap Analysis is based on the threats considered to have the greatest impact in each single MS and investigates the related policies, strategies and legislative instruments adopted to face it.

The level of intensity (from low to high pressure) is estimated on the basis of existing data and proven indicators. The degree of intensity of soil threats is an indicative measure based on open source peer-reviewed European datasets. Detailed data at national level and other indicators applicable for estimates of soil threats are available and could be considered for additional future research.

At the EU level there is a lack of systematic approaches for data collection and soil related indicators making comparison between MS difficult. It was therefore necessary to consider a harmonizing existing information and data. In this work, the aim is to assess the activities of the EU-28 MS to limit the negative impact of soil threats in the absence of a coherent EU wide legislative framework addressing soil degradation. Existing datasets were used to estimate soil threats, taking into account the limits of such an approach (e.g., the lack of data on certain threats for some MS, the difficulty in the interpretation of the data and outputs of different models and the lack of harmonized monitoring of soil threats among MS). These limits are considered in the discussion and the final conclusions. The specific threats considered for the gap analysis are:

- Susceptibility to erosion (water and wind)

According to recent studies (Panagos et al., 2016, 2015, 2017), approximately 11.4% of EU territory is estimated to have been altered by moderate to high-level soil erosion (more than 5 tonnes per hectare per year). This estimate is slightly lower than the previous one made in the early 2000s, which stressed that 16% of the EU's land area was affected by soil erosion. This reduced rate is mainly due to the application of management practices to combat soil erosion, largely applied

across MS during the past decade. As stated by Panagos et al. (2016), about 0.4% of EU land suffers from extreme erosion (more than 50 tonnes per hectare per year). Mean rates of soil erosion caused by water in the EU amounted to 2.4 tonnes per hectare per year. The total annual soil loss caused by water is estimated at 970 million tonnes. Wind erosion is less than water erosion as the mean rate of soil loss from wind in the EU amounted to 0.53 tonnes per hectare per year only in arable lands (Borrelli et al., 2017). The total annual soil loss from wind is 53 million tonnes.

- Soil organic matter decline (on mineral and organic soils)

Important soil functions depend on the presence of Soil Organic Matter (SOM) in soil. SOM affects the soil structure and, therefore, as with water retention, the soil stability and its propensity to landslides or flooding phenomenon, as well as the soil biodiversity and ultimately the overall soil fertility. The primary constituent of SOM is soil organic carbon. It has been estimated that around 45% of the mineral soils in Europe have low or very low organic carbon content (0–2%) and 45% have a medium content (2–6%) (de Brogniez et al., 2015; Lugato et al., 2014). The decrease of SOM is mainly due to human activity, specifically related to Land Use/Land Cover (LULC) changes from natural or semi-natural areas to agricultural ones, as well as the use of fertilizers or intensive crop rotation. The decline of SOM is widespread in all MS.

- Susceptibility to compaction

Soil compaction is a physical degradation process (Abdelrahman et al., 2016) that affects the porosity, permeability and other important biological, chemical and physical properties. It has been estimated that between 23–36% of the soils in Europe are highly susceptible to compaction while ca.18% are moderately compacted (Jones et al., 2012). About 33 million ha are affected by severe compaction, that is 4% of the area covered by the EU MS (Lamandé et al., 2018). The most significant areas affected by soil compaction are the northern and central part of Europe.

- Pressures on soil biodiversity

The Convention on Biological Diversity (CBD) defined the soil biodiversity as "the variation in soil life, from genes to communities, and the ecological complexes of which they are part, that is from soil microhabitats to landscapes" (United Nations, 1992). The decline is usually related to a deterioration of soil quality parameters that affect the living organisms in the soil.

It has been estimated that 14 MS have more than 40% of soil with moderate-high to a high level of risk for all three categories of soil biodiversity (soil microorganisms, soil fauna and soil biological functions). On the other hand, only five countries have more than 40% of their surface with low to moderate-low risk (Orgiazzi et al., 2016).

- Diffuse pollution

An important factor responsible for widespread soil contamination is the excessive use of agro-chemical products such as pesticides and mineral fertilizers in agriculture. These have a significant impact on soil biology communities (and thus soil functions), groundwater sources and, ultimately, on food safety. The impact of these practices is difficult to estimate because of their complex interaction in the water-soil system. Consequently, estimates of their spatial distribution are very varied. In Europe, the Western European MS have higher concentration of nutrients in soils due to greater use of fertilizers (FAO and ITPS, 2015). Specific studies on single contaminants, such as the recent studies dedicated to Copper distribution on topsoil, have highlighted that agricultural management practices in vineyards influence the concentration of this trace element in soil and groundwater. Copper

Table 1
Soil threats and related scientific references used for the analysis at EU level.

Soil threats	Scientific references
Susceptibility to erosion	(Borrelli et al., 2017; Panagos et al., 2016, 2015, 2017)
Soil organic matter decline	(de Brogniez et al., 2015; Lugato et al., 2014)
Susceptibility to compaction	(Abdelrahman et al., 2016; Jones et al., 2012; Lamandé et al., 2018)
Pressure on soil biodiversity	(Orgiazzi et al., 2016)
Diffuse pollution	(Ballabio et al., 2018; FAO and ITPS, 2015)
Soil sealing	(European Commission, 2012a; FAO and ITPS, 2015; Gardi et al., 2015; Prokop, 2011)
Salinization	(Daliakopoulos et al., 2016; FAO and ITPS, 2015; Jones et al., 2012)
Desertification	(Jones et al., 2012; Právělie et al., 2017; Stolte et al., 2015)
Landslides	(Wilde et al., 2018)
Contaminated sites	(Panagos et al., 2013)

distribution in the EU is particularly prevalent in France and northern Italy where viticulture is extensively practised (Ballabio et al., 2018).

- Soil sealing

Sealing is an irreversible process that consists in the transformation of open areas (natural, semi-natural or agricultural) into areas for settlement (e.g., residential, industrial, tertiary) or infrastructure. In other words, when the soil is permanently covered by an impermeable artificial material (e.g., asphalt or concrete), the topsoil, which provides most of the ES, is removed (European Commission, 2012a; Prokop, 2011). The only part of a settlement area that remains unsealed are areas like gardens, parks and other urban green spaces without im-pervious surfaces. The MS in Western Europe are those most affected by sealing processes (FAO and ITPS, 2015). A research by the European Commission (2012) has estimated that, between 1990 and 2000, at least 275 ha of soil were lost per day in the EU, amounting to 1000 km² per year, with half of this soil being sealed (European Commission, 2012a). Meanwhile, between 2000 and 2006, the average increase in artificial areas in the EU was 3%, with figures exceeding 14% in Cyprus, Ireland and Spain. Gardi et al., 2015 argued that considerable land use changes (2.8%) occurred in the EU during the period 1990–2000, compromising agricultural areas. By 2006, almost 100,000 km² (2.3% of EU land) was sealed, the land take from agriculture was calculated to be 752,973 ha for 1990–2000 and 436,095 ha for 2000–2006.

- Salinization

Soil salinization is an increase of salt in soils. It is considered to be one of the major soil degradation threats in Europe of natural origin (geological, climatic, topographic, and hydrological) or as a result of unsustainable human activities causing secondary salinization (Daliakopoulos et al., 2016), such as unsuitable irrigation practices using salt-rich irrigation water or poor drainage conditions (FAO and ITPS, 2015). Excess levels of salts affect around 4 Mha of European soils because of secondary salinization (Van-Camp et al., 2004), especially in the coastal areas of southern Europe (Daliakopoulos et al., 2016) such as Sicily, the Ebro Valley in Spain and, more locally, in other parts of Italy, Hungary, Greece, Portugal, France, Slovakia and Romania (Jones et al., 2012).

- Desertification

This process is defined as “land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities” (United Nations, 1994). The estimate of the area at risk of desertification is based on the combination of soil quality, climate and vegetation parameters. Desertification could potentially affect up to 2 billion people and 15 million km² of croplands (Právělie et al., 2017). The MS affected by this process are Bulgaria, Cyprus, Greece, Hungary, Italy, Latvia, Malta, Portugal, Romania,

Slovakia and Slovenia (Jones et al., 2012). Among 14 million ha (8%) of Southern, Central and Eastern Europe are highly sensitive to desertification and over 40 million ha (23%) are moderately sensitive (Stolte et al., 2015).

- Landslides and flooding

These two phenomena are considered major natural hazards, depending on a combination of natural, social, economic and ecological factors often related to climate and land use change. Landslides depend on the topography and therefore occur mainly in mountainous areas, while flooding is located along the major rivers in Europe and is related to human interventions that affect the natural drainage systems leading to waterlogging or flooding by river water. The recent study on European landslide susceptibility shows the spatial probability of landslides in the area of the Alps, Apennines, Pyrenees, Betics Carpathians and Balkans (Wilde et al., 2018).

- Contaminated sites

There is no comprehensive EU wide inventory of contaminated sites due to the lack of a common EU legal basis requiring their identification. In the survey promoted by the European Environment Agency (EEA), 30 of the 39 countries surveyed maintain comprehensive inventories for contaminated sites: 24 countries have central national data inventories, while 6 countries, namely Belgium, Bosnia-Herzegovina, Germany, Greece, Italy and Sweden, manage their inventories at regional level. In 2011,

It was estimated that there were 2.5 million sites potentially affected by local soil contamination in the EEA-39, of which about 45% were identified to date (Panagos et al., 2013).

The references used for the qualitative assessment of the data reported by EU MS on the various soil threats are briefly reported in Table 1 as follows:

Available data at EU level enables the intensity of threats that affect soils in the MS to be estimated (Fig. 1)

The different data and information used to estimate the extent and intensity of soil threats show an on-going soil degradation process in all parts of Europe (European Commission, 2012b). Despite the lack of a common EU framework for soil protection, existing national tools and legislative instruments in some MS directly or indirectly address soil degradation processes. Following the adoption of the EU Soil Thematic Strategy, a series of initiatives have increased awareness at EU level of the need for soil protection. Also, integration of soil protection measures in other EU legislation has been successfully implemented in many cases. Several EU Directives on Environmental Assessment including Directive 2001/42/EC known as “Strategic Environmental Assessment” – the SEA Directive - and Directive 2011/92/EU known as “Environmental Impact Assessment” – the EIA Directive, aim to ensure a high level of environmental protection during the decision-making process of projects, plans and programmes. There is also the Water Framework Directive (2000/60/EC) and the Nitrate Directive (91/676/EEC) which include measures to encourage sustainable agricultural

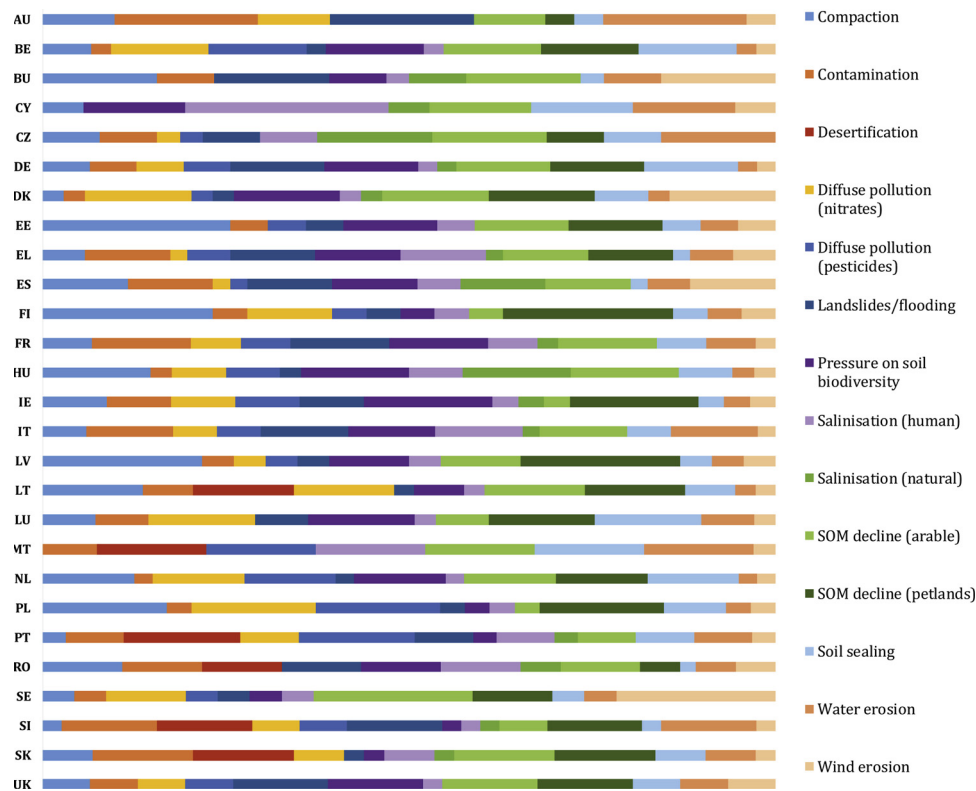


Fig. 1. The intensity of soil threats disaggregated for each EU Member State. The degree of intensity is an indicative estimate based on the scientific references reported in Table 1 (The value is not reported when not available).

practices, the Sewage Sludge Directive (86/278/EEC) that regulates sewage sludge on agricultural land and the Directive on Integrated Pollution Prevention and Control (96/61/EC) regulating emissions to air, water and soil from industrial sites. The Floods Directive (2007/60/CE) requires MS to assess and to map flood risk of all watercourses and coastal lines according to safety plan. As one of the main areas of EU legislation relating to soils, the Common Agricultural Policy (CAP) aims to prevent and mitigate soil degradation processes in agricultural areas by increasing or maintaining soil organic matter and soil biodiversity while reducing the erosion, contamination, and compaction of the limited soil resources of the EU. Given that agriculture occupies an important portion of European land, its contribution to the maintenance of soil resource is substantial. CAP is one of the EU's oldest policies, described since 1962 as addressing "good quality, safe and affordable food products while supporting European farmers" (Jones et al., 2012). Recently, CAP introduced such measures directly linked to soil protection as the Good Agricultural and Environmental Conditions (GAECs) that are a set of EU standards to be adopted at national or regional level for sustainable agriculture based on: maintaining the total area of permanent pasture, minimum level of maintenance, protection and management of water, soil erosion, soil organic matter, and soil structure (European Environment Agency, 2016). These different soil threats are directly included and considered in the CAP framework, while others, such as soil sealing, contamination, salinisation and shallow landslides, are not subject to specific CAP measures even if they contribute indirectly to degradation. For example, the measures for maintaining soil structure can contribute to the prevention of landslides. The new legislative proposal of the European Commission for the Post-2020 Common Agricultural Policy (CAP), presented on the 1st of June 2018 (COM(2018) 392 fin. 1) (European Commission, 2018), includes extensive references to the need to implement sustainable soil management within the future agricultural policy in the EU. In article 60, in particular, there is an explicit request to MS to include in their CAP Strategic Plans action on soil conservation, including the

enhancement of soil carbon.

Some of the above-mentioned measures are designed to regulate the anthropic practices that could affect the quality of soil even in the absence of a coherent EU framework that protects the soil resource. In fact, even if some threats are addressed and regulated by EU legislation (such as soil contamination, the loss of organic matter and soil erosion), others (such as the biodiversity conservation, soil sealing, compaction and salinization) are only vaguely considered and do not have a comprehensive framework for soil protection (Paleari, 2017).

3. Policy instruments in the European member states

This section summarises the policies, instruments, and strategies adopted by the MS for soil protection from the threats that affect the national soil resources with varying degrees of intensity.

The policy analysis explores whether a binding legal framework at EU level is now necessary. The analysis identifies gaps, overlaps or lack of coherence among different existing soil related policies.

Data are reported by MS and presented by a bar graph corresponding to the degree of the intensity of each soil degradation process from "low" to "high" indicating if, and to what degree, soil degradation processes affect the specific country. The common classification of soil threats, as adopted by the EU Soil Thematic Strategy, has been used to create a comparative statistic. The table also gives feedback of the quantity/quality of threats that affect the country.

3.1. Austria - AT

The soils of Austria are threatened by water erosion, flooding/ landslides, and contamination. As regards soil erosion by water, Austria has adopted different direct and indirect measures addressing the problem.

Even if national legislation does not govern the soil issue, there are soil-related legislative measures, such as the ones for erosion

containment, which play a role in limiting the threats. Among the various instruments, there are national laws on environmental protection, improving biodiversity and landscape management which also apply to flooding and landslides control. Additionally, some regional government instruments (such as national, federal, metropolitan and local land use plans) introduce a specific discipline for direct and indirect governance of these threats (e.g., *Österreichisches Raumentwicklungskonzept (ÖREK)*, *Raumordnungsgesetz*). Legislation at regional level embraces the strategic objective of preserving the national natural resources, soil included. Some regional legislation is explicitly devoted to soil conservation such as the Regional Planning Law of the Land Salzburg (last amended n. 39/2010). Moreover, the Spatial Planning Law of the Land Vorarlberg (last amended n. 54/2015) includes a definition of suitable land for agricultural and forestry purposes based on soil properties. It also introduces the Urban Growth Boundaries (UGB) at local level, thus avoiding urban fragmentation or an increase in built-up areas through urban sprawl. At the national level, the Austrian Spatial Development Concept (ÖREK) works as a strategic document for spatial planning, defining some general targets for land use plans at national, federal state, city and municipality level. Moreover, the ÖREK also includes the identification of priority “agricultural areas” and/or “protected green areas” for soil quality and landscape preservation, avoiding land becoming built over. Finally, Austria has set out a law on the remediation of contaminated sites (soil and groundwater), identifying threats to human health or the environment (*Altlastensanierungsgesetz*, n. 299/1989). The contaminated sites are ranked according to risk and priority of intervention.

3.2. Belgium - BE

Belgium is affected by different soil threats, including the decline and loss of organic matter (both in arable land and peatland). The agricultural practices aimed at protecting soil are governed by dedicated federal-state codes. For example, the federal state of Wallonia adopted an Agricultural Code (in force from 2014), that mentions soil as a natural resource to be protected from urban expansion. The protection of organic matter is also directly promoted by environmental policies where soil protection is listed as the main target to achieve. Based on the fifth Manure Action Plan (2015–2018), the federal states promote an integrated approach to improving water quality while considering the soil characteristics. The instrument aims to reduce the nutrient losses from the soil and to maintain organic matter, decreasing nitrate and phosphate concentrations in groundwater and surface water. Moreover, to spread the awareness of soil and its quality, there are databases specifically dedicated to soil, such as the *Taux de liaison au sol des exploitations agricoles TALISOL* used in Wallon. Other sectoral instruments have been adopted which relate to soil such as the Waste-Resource Plan in Wallon with content on organic and mineral waste (that are directly linked to soil management). Some policies directly address biodiversity loss phenomena, even if the strongest measures concern CAP *Greening* or the policy aimed at introducing an environmental evaluation of plans and projects (Strategic Environmental Assessment). Soil protection is also directly addressed by Audit instruments where the control of contamination and water quality is explicitly mentioned.

The important issue of the spread of pollution by pesticides or nitrogen is addressed through different dispositions aimed at avoiding environmental degradation of natural resources (soil and water). Lastly, the limitation of soil sealing is encouraged through some local legislation, which introduces rules for water pipes and filtering plants to reduce overflows and to slow down surface run-off.

Additionally, some urban planning instruments act at federal level to govern land use changes, achieving greater sustainability and limiting or compensating land take.

3.3. Bulgaria - BG

In Bulgaria, soils are threatened by wind erosion, the decline of organic matter and flooding/landslides risks. Soil protection is addressed at national level with programming and monitoring tools. In 1998, the Ministry of Agriculture and Food, in agreement with the Ministry of Environment and Water and Regional Development, set out a national law for the remediation of contaminated sites, agricultural activity and topsoil removal and recycling (Regulation n. 26 for Reclamation of Damaged Terrains, Improvement of Low Productive Soils, Removal and Utilization of the Humus Layer). Recently the Soil Act has been introduced which is a national law to prevent soil degradation. Among its principles is the “ecosystemic approach”, the sustainable use of soil, the *ex-ante* evaluation of soil state to prevent or limit its degradation, the promotion of good practices, the introduction of the principle that “polluters-pay”, and public awareness raising on the significance of soil functions. According to this regulatory framework, there are some soil monitoring instruments that operate in the context of the National System for Environmental Monitoring 3 which provides three levels of campaigns: level 1 – large scale monitoring using big data on specific soil indicators (metals, nitrates, organic carbon, pH); level 2 – evaluation of degradation processes, particularly the evaluation of the urbanization process using Corine Land Cover data (available at <http://land.copernicus.eu/pan-european/corine-land-cover>); level 3 – the collection of data on soil contamination using 15 regional agencies for this specific area. At the national level, the general directives for soil protection are also empowered by specific regulatory tools such as the national programme for sustainable soil management and desertification reduction (National Action Programme for Sustainable Land Management and Combating Desertification).

3.4. Croatia - HR

Croatia is threatened by erosion, soil compaction and flooding/landslides. In 2005, it adopted a national law aimed at managing the natural areas where soil is mentioned as a crucial resource that has to be protected from erosion by water and wind. The water cycle regulation is also included in the national law (*Zakon o šumama*). There are also some regulations concerning the monitoring of soil quality, such as law n.43 of 2014 on the monitoring of agricultural areas as well as the national project aimed at collecting a range of soil data (Project: SOC Stock Changes, Total Nitrogen and Total Organic Carbon Trends and C:N ratio in Soil).

3.5. Cyprus - CY

A significant soil threat in Cyprus is the salinization process, which is defined as the accumulation of salt in the surface layers of soils resulting in partial or complete fertility loss. The National Action Plan to Combat Desertification is the framework adopted in Cyprus in 1999, after the ratification of the United Nations’s Convention to Combat Desertification (UNCCD) in 1996, which introduced policies and measures to prevent the desertification process and promote the sustainable use of soil and water.

Such measures also address awareness raising of the population and its active involvement in limiting desertification. The plan also addresses salinization which is directly connected to the desertification process. Furthermore, the Drought Management Plan indirectly concurs in the management of soil and acts against the salinization process, although its main goal is to combat water scarcity by preventing water waste and increasing the production of desalination plants and by building water reservoirs.

3.6. Czech Republic - CZ

Among the various soil threats, the decline of soil organic matter

(specifically in croplands) is particularly significant. The loss of organic matter happens mainly in arable areas due to agricultural practices. The majority of national policies related to soils address these practices. In addition to the CAP measures, the Rural Development Programme 2014–2020 promotes measure for sustainable soil management to increase the carbon storage through afforestation. The Czech Republic also introduced regulatory dispositions to define some agricultural practices aimed at increasing the level of sustainability. An example is given by Law 156 of 1998 concerning the use of fertilizers and Law 262 of 2012 that identifies the zones affected by excessive nutrients. In the legislation, there is an explicit mention of the decline of soil organic matter and soil erosion in determining the thresholds for the levels of fertilization and the kind of agricultural practices that are not authorized in the presence of strong erosion. Some monitoring actions were also introduced to measure the trend of soil quality in order to detect the physical and chemical state of soils every five years. Different land uses are subject to this monitoring programme on a national scale: croplands, pastures, vineyards and fruits. The Czech Republic also uses the regulatory approach to contrast the loss of biodiversity, such as Law 156 of 1998, which determines the use of fertilizers and promotes the greening measures of CAP. Indirectly, there are also tools for monitoring soil pollution and pests (*Bazální monitoring půdy*), to control soil quality and additional measures aimed at increasing the biodiversity (Nature Protection Act 114 of 1992 and Water Act number 254 of 2001). Lastly, National Law 334 of 1992 establishes measures to protect the quantity and quality of agricultural land, introducing monitoring actions against pollution, degradation, compaction, desertification and erosion.

3.7. Denmark - DK

Different phenomena pose a serious threat to Danish soils. Amongst these is erosion caused by wind. There is no adequate system of protection against this threat. Instead there are some regulative tools which have an indirect positive impact on erosion (Act on Surveying, Preventing and Remedying Environmental Damages rather than the Act on Agricultural Use of Fertilizers and on Plant Cover). The act adopts the principle of “polluters-pay” defining the environmental damage and how to establish responsibility or to remedy it. Moreover, different actions and strategies are addressed to regulate the agricultural use of fertilizers and to set requirements for plant cover and other management practices to reduce leaching of nitrate. In addition, to avoid the decline in organic matter (both in agricultural areas and in peatland), CAP measures support soil protection and carbon stock conservation (such as the creation of pastures, the establishment of green buffering areas along the borders of farmlands and the introduction of vegetated areas on uncultivated land). Soil threats are also indirectly managed by regulatory instruments promoting the conservation of organic matter by protecting natural areas (e.g. rules to prevent the contamination of watercourses, lakes and the sea). These actions are specifically designed to prevent contamination of water bodies but are important also for soil protection. The pressure on biodiversity is addressed by a specific national Act on taxation of pesticides, adopted in 2013, containing some fiscal measures to reduce the use of fertilizers and harmful pesticides. Soil protection is not explicitly mentioned in the Act, but the effect of the pesticides on earthworms is included in the calculation of the tax. Lastly, contamination is addressed by direct regulatory tools connected with the introduction of more sustainable agricultural practices. One of these is the Departmental Order on the Use of Sewage Sludge in Agriculture which regulates the kind and quantity of waste that can be used for agricultural purposes. There is also the National Act on Environmental Approval of Husbandry Farms (in force since 1992) which aims at preserving the landscape and natural environment as well as agricultural activity (to ensure that husbandry is sustainable and compatible with human life).

Additionally, some monitoring programmes aim to share

information and good practices on soil management and are dedicated to supporting the regional action that introduces measure against soil contamination.

3.8. Estonia - EE

Soil compaction and land take pose serious threats to the soils of Estonia.

Concerning compaction, Estonia has adopted some regulatory tools for soil monitoring and to prevent further damages. The main legislative measure is the Estonian Environmental Strategy 2030 based on the principle of sustainable development as a basis for the institution of sector-specific development plans.

The strategy outlines four specific soil targets promoting sustainable use of soil resources: 1) the development of an integrated policy for soil protection; 2) the development of an adequate monitoring system for land uses and land use changes; 3) the development of awareness raising actions for landowners keeping high-quality land for agricultural activities; and 4) the creation of incentives and benefits for the sustainable use of soil. Moreover, in 2003 the National Land Improvement Act was adopted, outlining some activities to improve soil quality such as actions on drainage, irrigation, run-off control and the improvement of sustainable agricultural practices to increase the level of fertility.

Since 1994, Estonia has had in place a National Environmental Monitoring Programme which is mainly dedicated to water and air quality as well as wildlife trends. Between 2000 and 2001, it included a sub-programme dedicated to agricultural land. This consisted in a field campaign for determining the geological characteristics of different soils and measuring the main indicators, such as fertility, the presence of pesticide residues or heavy metals, and various basic soil parameters. In 2015, a regional programme to support soil protection was introduced to the CAP 2014. The programme provides financial support for organic farming, promoting soil protection and an increase in organic matter. The financial contribution is provided only after careful diagnosis of soil properties aimed at verifying whether or not the chemical or physical characteristics of the land have been altered. Furthermore, monitoring is regularly undertaken until the end of the founding period. Lastly, Estonia applies indirect instruments that support to soil regulation and help to reduce compaction. Amongst these is the Planning Act of 2015 and the Environmental Impact Assessment and Environmental Management System Act of 2005. Both the Acts consider the environmental assessment (SEA and EIA) as essential procedures for protecting soil functions and the landscape, including the social, economic and cultural aspects.

3.9. Finland - FI

In Finland, soils are threatened by the decline of organic matter, compaction and contamination.

To reduce the decline of organic matter, Finland has set up different types of instruments, which are connected to the CAP. Other regulatory instruments contain specific goals for soil protection at the national level, such as the Government Development Programme for the Organic Product Sector and Objectives to 2020 that promotes sustainable agricultural practices to increase organic production, diversifying and improving access to organic food. In 2012, the Finnish Government adopted a resolution on the sustainable and responsible use and conservation of mires and peatlands promoting responsible use of soil resources for drainage purpose. Finland has addressed the problem of soil compaction through the national programme called “Soil Remediation under State Waste Management System” which was launched in 1997 to improve water drainage in urban areas through porosity and to avoid ompaction of urban surfaces. The economic programme recognizes that the improvement of hydrological conditions affects soil properties and the management of productivity. Soil contamination in Finland is one of

the main threats not properly addressed by specific measures. There are some fiscal instruments, such as the National Programme for Soil Remediation under State Management System for waste management and contaminated sites, that provides economic support for its remediation.

Specifically, the programme acts when the contamination could affect human health and/or the environment, introducing responsibility and rules for remediation. Prevention of the contamination is addressed by regulatory instruments such as the recent “Decree on the Assessment of Soil Contamination and Remediation Needs” (214/2017) which refers to the contamination assessment and the related procedures of remediation.

Subsequently, the Act on the Remediation of Certain Environmental Damages no. 383/2009 was passed. It was placed within the framework of the European Environmental Liability Directive 2004/35/CE on environmental responsibility in the field of environmental damage prevention. The national law includes remedial measures for environmental damages through the Environmental Protection Act (572/2014), which defines the authorization process for evaluating the state of the environment and contamination. Furthermore, contamination monitoring occurs through other informative tools, such as the “Geochemical baselines” service of GTK, in force since 2009 at national level, which determines the regional geochemical characterization of the soil, including the concentration of contaminants in specific sites. Accordingly, the National database of soil status, in force since 2012, provides quantitative and qualitative information on contaminated sites and the actions for land reclamation.

3.10. France - FR

Many factors threaten the soil of France, such as the decline of the organic matter, the loss of biodiversity, contamination, erosion and flooding/landslides risks. Such threats are addressed by different regulations in various policy areas:

- Planning (*Code d'Urbanisation* in force since 1954). The Code is the main Act that brings together all legal and regulatory instruments in pursuit of sustainable development, such as the application of regional and local Plans and Programmes (SCOT – *Schéma de Cohérence Territoriale*, PLUi - *Plan Local d'Urbanisme Intercommunal*).
- Environment (*Code de l'environnement* in force since 2000). The Code defines a set of tools and measures to prevent pollution and environmental risk and to avoid potential damages to human health. The Code sets out actions to prevent soil pollution and considers soil quality as the essential parameter in defining the natural protected areas and Natura 2000 sites.
- Rural areas (*Code rural et de la pêche maritime* in force since 1979). The Code encourages landowners to pursue common targets of agricultural management or to promote the quality certifications for some products, based on soil quality (e.g., wine production), to create and assemble into associations.
- Forests (*Code Forestier* in force since 2012). The forest code is an attempt to balance the economic, ecological and social regulations of forest areas and it is aimed at favouring sustainable and multi-functional management of these natural reserves. Moreover, the Code recognizes the protection and nitrogen fixation in forest soils to avoid erosion, flooding and favours the carbon pooling property of forest soil, especially in mountain areas.

In addition to these instruments, there are also fiscal and regulatory measures associated with CAP that indirectly address the issue of soil protection (e.g., Tax Incentives Related to Soils). Lastly, in a scientific interest group on soils (*Groupement d'intérêt scientifique Sol - Gis Sol*) was established to constitute and manage an informative system for monitoring purposes.

3.11. Germany - DE

In Germany, soils are threatened by contamination, organic matter decline, loss of biodiversity, sealing and flooding/landslides. To address these phenomena, Germany has adopted different instruments aimed directly at soil conservation. Besides the regulatory instruments and fiscal measures settled by the CAP (greening and the cross-compliance standards), there are also tools for soil monitoring such as the National forest soil inventory with the aim of providing a detailed description of the forest soil conditions (chemical composition, physical structure, organic matter, biodiversity and vegetation). The inventory shows where soils are threatened by phosphorous contamination, climate change and unsustainable forest management. In addition to such surveys, a long-term monitoring programme (*Boden-Dauerbeobachtung BDF*) has been established to observe and track the changing condition of soils and related functions. The programme aims at providing a constant upgrade of data on cropland, grassland, forestry and other special uses (e.g., for winegrowing). The monitoring instruments also include an information system dedicated to soil condition (*Bodeninformationssysteme*) which gathers all the information from different research databases that is useful for supporting the policy orientation. Specific research projects also enhance knowledge of the soil threats. One of these is the agricultural soil inventory (*Bodenzustandserhebung Landwirtschaft*) which aims to assess the organic carbon content in agricultural soils, studying the interaction of climate data with the land use and defining possible scenarios. The research programme was set up in 2008 and will end in 2018. The dissemination of scientific and non-scientific knowledge of soil and its threats is guaranteed by some interactive channels (such as *Soil Maps DE (2015): Atlas-Informationssysteme*) and by events organized in schools where environmental education is crucial in spreading awareness.

From a regulatory perspective, three main acts regulate soil protection. The first is the Federal Soil Protection Act, in force since 1998 and recently modified (2015), which aims to protect soil and maintain its function with the ecosystem avoiding, in particular, any contamination (including water contamination) and promoting land remediation.

The second act is the Building Code which defines the soil as a common good and considers the ecological compensation and significant negative environmental impacts.

The third act is the National sustainable development strategy which is articulated with political targets, and long-term monitoring indicators like the land take threshold, which aims to limit the land take to an average of 30 ha/day until 2020 and within the next few years. There are also other regulatory tools such as the Fertilizer Act which became law in 1962 to preserve and increase soil fertility, promoting sustainable agriculture, lowering its environmental impacts and avoiding consequences for human's health and the Mining Act which regulates the extraction of mineral resources.

3.12. Greece - EL

The soils of Greece are threatened by many types of degradation: a decline of the organic matter, loss of biodiversity, salinization, contamination, land take, landslides/flooding and erosion. Soil protection in Greece has been addressed recently by a national legislative proposal for soil protection and its sustainable use. The Bill is still under discussion (in 2017), and it was proposed to the national Parliament in 2014. It contains arrangements to prevent soil pollution and avoid land take, an inventory of contaminated sites and programmes to regenerate them as well as the definition of a national strategy to reclaim the contaminated areas in specific sites such as ports, airports and waste sites. At national level, the Law no. 1650/86 for the protection of the environment is in force, which does not consider the introduction of direct measures to protect soil but delegates its application by a series of sectorial legislative acts. Previously, in the absence of a specific

national law for soil protection, many regulatory instruments were adopted for specific areas such as the national action plan for combating desertification (adopted in 2002) which defines the guidelines to avoid such threats. Nonetheless, the plan does not define the application and the adaptation of the guidelines at a local level.

3.13. Hungary - HU

The soils of Hungary are threatened by a decline in organic matter, compaction, decreasing biodiversity and salinization. Such threats are mainly addressed by regulating agriculture and its relative impacts.

Besides the CAP measures (Greening and Cross-compliance Standards) and the application of a number of regulations on for the use of fertilizers in agriculture that define specific objectives for soil conservation, Hungary has passed a national law to regulate agricultural practices (1994). The national legislation aims to preserve the organic matter, adopting a form of taxation to protect soil and a common regulation to manage agriculture practices and for agricultural land acquisitions (*földvédelmi járulék*).

The protection of agricultural land is also addressed by the Fourth National Environmental Remediation Programme 2015–2020, preceded by other National programmes (NERP-I: 1997–2002, NERP-II: 2003–2008, NERP-III: 2009–2013), with the goal of creating a common strategy for environmental protection, also including the preservation of soil fertility. Furthermore, the Strategy for Sustainable Development (2012–2014) promoted the conservation of organic matter, recognizing the value of soil and the need to protect it from various threats. Recently, the second National Climate Change Strategy (2014–2025) has been outlined, which deals with the role of soils in mitigating climate change mitigation process as well as the effects that the variability of weather has on cultivated soils. Among the measures, the strategy supports the application of sustainable agricultural practices, in order to lower the impact of agriculture on the fertility and quality of the soil. The evaluation of soil quality is monitored by an information system (Soil Information and Monitoring System, SIMS) which is coordinated by the Research Institute for Soil Science and Agricultural Chemistry (RISSAC) of the Hungarian Academy of Sciences. The system's main goal is to monitor the changes in soil characteristics such as acidity and carbonate status, texture, depth of humus layer, hydrophysical categories, available moisture content, phosphorous, potassium and heavy metal content.

3.14. Ireland - IE

Factors which threaten the soils of Ireland, include a decline in organic matter on peatlands and the relative loss of biodiversity. In 2002, Ireland put forward a proposal for a national strategy for the protection of soil, which is still under consideration (Developing a Soil Protection Strategy for Ireland). The proposal aims to develop a system to monitor soil quality, which is based on quantitative and qualitative indicators of the impacts caused by the land use changes. In view of the above-mentioned threats, Ireland has addressed the decline in organic content and the loss of biodiversity with some direct regulatory tools aimed at conserving resources. The instruments include a National strategy (National Peatlands Strategy) to protect and manage wetlands and all types of peatland, independently of their size. The target of the strategy is to define a common management system on soil conservation and to share some principles and issues to be considered in regional and local land use planning. The strategy has been developed in a joint agreement with landowners and other stakeholders to increase the awareness of its value. Additionally, Ireland applies CAP measures (Greening and Cross-compliance Standards), and has adopted guidelines for waste management that consider the use of sewage sludge for agricultural purposes (Waste Management - Use of Sewage Sludge in Agriculture - Regulations) to protect soil from incorrect nutrient management of agricultural areas, fixing the maximum threshold for metal

concentrations. In addition, there is the Nitrate Regulation (2006) that fixes the maximum quantity of phosphorous allowable from animal manure (170 kg/ha/year).

As regards the natural forest areas, the Forestry Programme 2014–2020 embraces four goals:

- To increase the wood cover and the carbon stock content in the soil;
- To increase the forest biomass production to produce energy from natural resources;
- To support landowners for increasing agricultural production;
- To maximize the operation of ecosystem services in natural areas.

Lastly, since 2007, Ireland has had an information system on soil (Irish Soil Information System) with a wide set of geological data and maps to increase knowledge and facilitate the decision-making process on land use transformations.

3.15. Italy - IT

In Italy, soils are affected by a number of threats: land take, contamination, decline of the organic matter in croplands, water erosion, landslides and flooding, loss of biodiversity and salinization. Beside the CAP regulation, soil management is directly addressed by a range of tools, among the many:

- The Environmental Code (no. 152/2006) is the regulatory framework for any environmental issues including soil protection and prevention of desertification with regards to hydrogeological risk;
- the National Strategy for Climate change adaptation, adopted in 2015, includes the issue of soil degradation and desertification related to climate change, defining the measures of protection and the global warming mitigation with reference to UNFCCC;
- The National Biodiversity Strategy which came into force in 2010, is derived from the ratification of the UN Convention on Biological Diversity with law 124/94. The strategy includes specific measures for soil protection and restoration to guarantee sustainable agricultural practices and management of soil, forest and water.

There is also the Italian landslides inventory devoted to data collection on landslides phenomena and two other decrees concerning soil protection:

- the Decree on Sewage Sludge (no. 99/1992) regulates the use of sewage sludge in agriculture to limit the possible negative effect on soil and to maintain its organic matter;
- the Decree on Regional Waste Management Plans (no. 152/2006) aims to regulate waste management in the Italian regions, identifying measures on landfill to avoid contamination.

Most of the measures are related to agricultural activities, while specific instruments address the forestry regulation. The Protocol of Soil Conservation of the Alpine Convention (no. 50/2012) aims to reduce quantitative and qualitative soil impairments, minimizing the detrimental impact on the control of erosion and the limit of sealing. There is also the Legislative Decree on Orientation and Modernization of the Forestry Sector (no. 227/2001) that sets the regulatory framework for the management and protection of forests.

3.16. Latvia - LV

In Latvia, soils are threatened by compaction phenomena and by the decline in organic matter in peatlands.

Soil compaction is addressed by the Natural Resources Tax Law, in force since 2006. It consists in a fiscal instrument which aims to promote a cost-efficient use of natural resources, to limit environmental pollution and the production of polluting substances, to encourage

sustainable economic development and to support financially environmental protection measures. The law fixes natural resources tax and rates (set by the Cabinet of Ministers Regulations No. 404 of 19 June 2007), making their use subject to a specific permit. In addition to this fiscal instrument, there is also the Environmental Policy Strategy 2014–2020 that defines the objectives for environmental protection and conservation in the medium term. As regards planning, there is the General Regulation for the Planning, Use and Building of the Territory (in force since 2013), that requires ensuring the protection of (green) territory in the planning of houses, yards, outdoor spaces and recreational areas, using parameters of building density. The regulation also includes a consideration of the hydrogeological risks, contamination and landscape conservation, avoiding new built-up areas on ground at risk of erosion and landslides/flooding. Besides CAP measures that directly address the compaction and the organic matter decline, Latvia manages organic matter through specific regulations on the control of agricultural activities. The Regulation regarding use, monitoring and control of sewage sludge and its composts aims to avoid soil contamination, defining special requirements for use of sewage sludge and its compost in various applications, while the regulation regarding protection of water and soil from pollution with nitrates caused by agricultural activity is aimed at protecting water and soil from nitrate pollution. The control and management of the contamination are addressed by the Law on Amelioration, in force since 2010, which aims to promote sustainable use of natural resources at the same time as providing the development of the infrastructural system and urbanized areas. The law includes provisions for the amelioration financing and establishes the recovery procedures according to the intensity of the damage.

3.17. Lithuania – LT

The soils of Lithuania are affected by compaction, decline of soil organic matter (in croplands and peatlands) and the spread of contamination. Soil protection has been guaranteed by the Law on Environmental Impact Assessment since 1996 and updated in 2013 by law no. XII-418 which directly addresses threats (contamination, loss of biodiversity, wind and water erosion, sealing) and provides mitigation measures for reducing impacts. The value of soil and the importance of protecting it from different threats are included in the National Strategy on Sustainable Development, in force since 2003. The strategy aims to reduce erosion by increasing forests land, perennial vegetation areas and protected areas, to avoid contamination and to restore quarries and mining sites. Moreover, among the objectives, there is also a plan to establish by 2020 a public access data system for contaminated and potentially contaminated sites.

In addition to these instruments, there are regulatory measures for agricultural activities which aim to avoid the threat of diffuse soil contamination and loss of organic matter:

- The Programme on Water Pollution Reduction from Agricultural Sources in force since 2008, directly implements the contents of the Nitrate Directive to combat erosion and preserve fertility;
- The Environmental Protection Requirements for Manure and Slurry Management, in force since 2005, aims at reducing the environmental pollution caused by agricultural management.

Local soil contamination is addressed by the Regulations on Contaminated Sites Treatment Procedures, providing a common monitoring system that evaluates the degree of contamination related to heavy metals and inorganic compounds, aromatic hydrocarbons, polycyclic aromatic hydrocarbons, halogenated hydrocarbons and pesticides. Moreover, sectorial measures were adopted to prevent threats, such as the Law on Protected Areas, in force since 1993, which aims to preserve ecosystems and promote ecological farming. The law defines soil as one of the structural elements of landscape, with regulations on

avoiding land use changes in natural protected areas and promoting protection in areas along rivers and water bodies. Additionally, there is the law on Forests (no. I-67) to regulate reforestation, forest protection and forest use.

3.18. Luxembourg - LU

In Luxembourg, soils are affected by the decline in organic matter, loss of biodiversity, diffuse contamination and soil sealing. The first three threats are addressed by instruments for regulating the agricultural activity and the use of fertilizers to reduce the environmental impact.

Among the instruments are the regulatory measures of CAP (Greening and Cross-compliance Standards) and the Rural Development Programme 2014–2020, which aims to improve soil management, directing farmers toward more sustainable practices with agri-environmental commitments. There are also regulatory measures for the use of nitrogen fertilizers in agriculture and for the use of sewage sludge, to prevent agricultural activity from contaminating soil and water. The loss of biodiversity is included in the *Loi du 19 Décembre 2008 relative à l'eau*, which aims to reduce the contamination of water bodies and to improve the chemical and ecological state of the rivers. Many of the objectives are directly connected with soil protection in order to reduce and limit contamination, protecting the ecosystem (such as the wetlands) and preventing erosion. Accordingly, the law on waste management (2012) considers contaminated soil as “waste” and therefore it should be dealt with following a specific procedure. The decline in soil organic matter is addressed by monitoring instruments based on two National initiatives:

- 1 The National Environmental Soil Monitoring, financed by central government with the aim of measuring the soil texture, pH, organic carbon content, nutrient content, heavy metal concentrations, organic pollutants and microbial and faunistic parameters.
- 2 The National Environmental Land Cover Monitoring is a database composed of 76 types of soil uses; it supports the decision-making process at national level while monitoring Land use changes.

The threat of soil sealing is mainly regulated by planning activity. The “Law Concerning the Evaluation of the Environmental Impacts of Certain Plans and Programmes” is based on the assumption that planning instruments have a direct impact on soils. There is also a Master Programme for Spatial Planning, in force since 2003 that defines measures for the long-term protection of the functions of the main components of the natural environment, including the promotion of sustainable management of soils and natural resources. The Master programme aims to coordinate the different planning levels (regional, local and sectorial) with regards to transport, infrastructural systems and planning to reduce urban expansion, avoiding soil sealing and protecting landscape and environment.

3.19. Malta - MT

In the case of Malta, different data on soil threats is not available therefore it is not possible to estimate the severity of each threat. Existing data indicates that soils are strongly affected with high intensity by: the decline in organic matter, water erosion, sealing and the diffuse pollution caused by pesticides and salinization. Management of the threats is included in a regulatory instrument that addresses the pressure in to provide strategies and rules for soil protection and conservation. Among the many measures are those of the CAP, the National Environment Policy in force since 2002, the Strategic Plan for Environment and Development of 2015, all of which promote sustainable use of natural resources (including soil) and their protection from sealing, erosion and contamination.

Malta has also approved other specific instruments to combat the

phenomenon of contamination, in line with European directives such as the Nitrates Action Programme Malta, in force since 2011, that includes limitations on the application of fertilizers on land, and the Sludge (used in agriculture) regulation of 2001 which aims to prevent harmful effects to soil, vegetation, animals and human health.

3.20. Netherlands - NL

A range of high-intensity threats affect the soils of the Netherlands such as compaction, land take, decline in organic matter, sealing, contamination and loss of biodiversity. Besides the instruments promoted at European level (CAP and directives to prevent contamination from the use of fertilizers and nitrates), the Netherlands has other regulatory measures for limiting the degradation. The Soil Protection Act, in force since 1987, is the national framework for soil quality protection that will become part of the integrated Environmental and Planning Act in 2019. The Act aims to limit land use changes and regulate the application of waste, contaminated water or sludge in the soil. Furthermore, from 2008 the Soil Quality Decree (*Besluit bodemkwaliteit*) was adopted aimed at overcoming such problems within existing legislation and to guarantee a balance between socio-economic purposes and soil protection. The Decree is divided into three parts: 1) a minimum requirement for soil quality; 2) the regulation of the environmentally safe use and reuse of stony building materials; 3) to set respectful-soil-criteria while running sludge dredge activities. Compaction and the loss of biodiversity are addressed through the erosion regulation which defines important measures for agricultural activities with the aim to protect the soil by ploughing and catch crops. Contamination is addressed by different instruments with specific measures taking into account the natural resource involved. The Water Act regulates the management of surface water and groundwater, and also improves synergies between soil, water and possible uses outlining ways of capturing it and the disposal of rainwater. A different monitoring system provides information and data on soil and also makes reference to some indirect impacts of a specific plan or programme.

3.21. Poland - PL

In Poland, soil is affected by threats with high-intensity threats such as compaction, the decline in organic matter and contamination. The first two threats are regulated through instruments that address the agricultural activity such as the CAP (Greening and Cross-compliance Standards) or the Code of Good Agricultural Practices, in force since 2004, that aims to implement National, EU and international environmental legislation in agriculture. In the code, specific attention is paid to protection, avoiding erosion phenomena, the decline in organic matter and the promotion of biodiversity.

Other regulatory instruments are dedicated to the forestland, such as the law on forests, in force since 1991 (*Ustawa o Lasach*), with the aim of protecting the forest and ecosystem services. The law allows “protective forests” to be given special status because of their role in conserving soil from erosion, contamination, decline in organic matter and landslides. In addition to this, there is the Environmental Protection Law, adopted in 2001, that includes a chapter dedicated to “Land Surface Protection” providing measures against diverse soil threats including contamination, erosion, organic matter decline, acidification, landslides/flooding, compaction, and salinization. Three years later, the Nature Conservation Act was adopted to promote the conservation of natural resources through their sustainable use. The Act on Preventing and Remedying Damage to the Environment, adopted in 2007, addresses the issue of contamination including the implementation of the principles of “prevention at source” and the “polluter pays”. The Act also introduces an environmental remediation plan, which is activated in the case of damage where information on soil characteristics and contamination type is available.

3.22. Portugal - PT

In Portugal, soils are affected mainly by the spread of pesticides contamination.

The instruments adopted to regulate the soil threats directly are mainly related to the agricultural practices to improve the soil fertility, minimize erosion and protect it from pollution, and to regulate the use of sewage sludge. One of many laws is the Law on the Use of Sewage Sludge on Agricultural soils in force since 2009, the Law on the Distribution, Sale and Application of Plant Protection Products for Professional Use and the Manual of Agricultural Good Practices, adopted in 2009, which is dedicated to soil and water conservation. Moreover, specific measures on water contamination are included in The Water Law (no^o 58/2005) that establishes the framework for the management of water resources to improve their ecological and chemical status. Ultimately, the environmental policy act (no^o 19/2014) regards soil protection defining actions for sustainable use of resources and ecosystems for a carbon-free society.

3.23. Romania - RO

High intensity threats which affect the soils of Romania include compaction, the decline in organic matter, landslides/flooding, salinization and the loss of biodiversity.

Many of the above-mentioned threats (compaction, organic matter decline, landslides/flooding) are addressed by the Decision on the Assessment of the Effects of Certain Public and Private Projects on the Environment which also includes the contents of the Environmental Impact Assessment (EIA) Directive, replacing the procedure with new screening arrangements and criteria. The Law on Afforestation of Degraded Land aims to achieve soil protection and reclamation, the recovery of the hydrological balance and an improvement in environmental conditions. All types of ownership are involved in the regulation of the law. Moreover, contamination and degradation are also regulated by specific instruments such as the Law on Land Reclamation or the Ordinance on Environmental Liability, based on the “polluter-pays” principle, to prevent and recover environmental damage.

3.24. Slovakia - SK

In Slovakia, soils are mainly threatened by contamination and the loss of organic matter.

Soil protection is governed by the National Soil Protection Act that promotes sustainable use of agricultural land, as well as prescribing the rules for changes from agricultural to non-agricultural land (the land take process). The soil quality is monitored by a programme called “Monitoring of Environment (Partial monitoring system – Soil)” consisting of ten partial monitoring systems. It has been in force since 1990 with data on contamination, acidification, salinization, quantitative and qualitative characteristics of the organic matter, nutrients, compaction and erosion. Different regulatory measures address contamination and are mainly focused on agricultural activities and on the regulation of chemical substances. The other existing legislative Acts adopt the “polluter pays” principle outlining procedures for soil and water remediation. In conclusion, measures to limit the decline in organic matter are also based on the CAP (Greening and Cross-compliance Standards).

3.25. Slovenia - SI

In Slovenia, the high intensity threats to soil are contamination, the decline in organic matter, water erosion and landslides/flooding. Protection is mainly regulated by legislation on the agricultural activities and the use of fertilizers, sewage sludge and the use of nitrates. Agricultural practices and soil use are also addressed by CAP measures (Greening and Cross-compliance Standards) and the Agricultural Land

Act, in force since 1996, which has 3 goals: 1) to protect and improve the productive potential and availability of agricultural land for food production; 2) to ensure sustainable management of fertile soils; and 3) to maintain landscapes and promote rural development. The Act is implemented at local level through planning instruments and a strong contractionary fiscal policy for the land use changes in highly productive croplands. The degradation of soil caused by erosion or landslides is addressed by the Water Act and Delegated Regulations for Erosion, Flooding and Landslides with the aim of achieving a good quality of water, regulating its use and hydro-morphological management through a national programme for water protection. Furthermore, the Act introduces the concept of areas that are at risk of flooding, erosion, and landslides. A decree on the status of soil (*Uredba o stanju tal - Osnutek*) has recently been set out that addresses the degradation of soils resulting from current or past human activity, with the associated risks for human and environmental health.

3.26. Spain - ES

The soils of Spain are affected by many high intensity threats such as compaction, land take, contamination, a decline in organic matter, erosion, landslides/flooding, loss of biodiversity and salinization. There is no specific regulation that directly addresses the threats of compaction and salinization. The decline in organic matter and contamination are regulated through measures which refer to agricultural practices such as CAP (Greening and Cross-compliance Standards), Royal Decree 1416/2006 to Decommission Petroleum-Product Tanks (no. 1310/1990), the Decree on Protecting Waters from the Pollution by Nitrates Derived from Agricultural Sources (no. 1311/2012), or the State Framework Plan for Waste Management (2016–2022). Furthermore, according to EU Directive 96/61/CE, the Law for Integrated Pollution Prevention and Control (no. 16/2002) was adopted that establishes the procedures and limits for polluting emissions (covering air, soil and water) for industrial operations. The protection of soils from wind erosion and landslides/flooding is addressed mainly by instruments devoted to forests and their management such as the Forestry Law (no. 43/2003) that establishes the National framework for preventing forest fires, reducing land degradation and restoration of land. On the same issue, the Spanish Forestry Strategy adopted in 1999, and the Spanish Forestry Plan of 2002, also promotes development based on sustainability and a recognition of the multi-purpose use of forests and their contribution to territorial cohesion.

3.27. Sweden –SE

In Sweden, soil is affected by two high intensity threats: the decline in organic matter and wind erosion. Both threats are regulated through the CAP instruments of Greening, Cross-compliance Standards and the Rural development programme (2014–2020). The latter aims to achieve 35% of agricultural land under management contracts to improve soil management and/or prevent erosion. Soil protection is also governed by the Strategy for Sustainable Land Use - not yet completed – in which soil's importance as a carbon sink in the reduction of Greenhouse gas (GHG) emissions is highlighted. In the strategy, the concept of green infrastructures for sustainable management of the environment and built-up areas is also introduced.

3.28. United Kingdom – UK

The soils of the UK are strongly affected by a decline in organic matter (both in agricultural areas and in peatland), landslides/flooding and loss of biodiversity. Despite the measures introduced in recent years through CAP (e.g., Greening Payment Requirements or Cross-compliance standards) and adopted by each country within the UK, the decline of soil organic matter and landslides are addressed at national level by the UK Forestry standard (since 1998 and subsequent updates).

It sets out guidelines for requirements on the definition of soil, regulations and monitoring for wider environmental protection. Furthermore, the state of soils is monitored through the Countryside survey a long-term process to assess the status of the UK's countryside, aiming to provide a collection of data on environmentally-related issues to policy-makers. Besides this, each country has developed other specific instruments that explicitly address this threat (e.g., the England Catchment Sensitive Farming Programme, the Soil Indicators for Scottish Soils, the Wales Glastir Monitoring and Evaluation Programme or the Land Strategy for Northern Ireland).

Biodiversity protection is regulated at the national level by a number of acts which explicitly address it such as: the Agricultural Land (Removal of Surface Soil) Act, the Nitrate Pollution Prevention Regulations, the Pesticides Control Legislation or the Sludge (Use in Agriculture) Regulations.

4. Results and discussion

4.1. Policy highlights

As stated in the introduction, the lack of an EU Soil Framework Directive is weakening the possibility of straightforward coordination on strong soil regulation among MS.

The situation among the different MS is contrasted with the shared assumption that soil is a common, limited resource, all over the world. Even if its morphogenetic characteristics vary its management should be unified, promoting safer and healthier conditions for all European citizens. The fact that each MS is acting without the umbrella of common legislative coordination is a sign of political weakness that needs to be addressed. As an example, the contamination thresholds of urban soils vary across MS, and the soil remediation costs are largely dependent on this parameter. Contamination is a threat that affects human health equally and, as a matter of urgency, threshold levels of contaminated soil should be commonly shared.

The lack of common regulation has many knock-on effects.: when considering urban regeneration in previously urbanized soils, if there is not a uniform contamination parameter among MS, investments in re-qualification will prioritise countries where the threshold is lower. As a consequence, the property market and investment preferences will be strongly affected by the absence of a common soil policy.

The following highlights summarize the analysis of results.

Austria - AT

- 1 There is no national law on soil protection although there are federal planning Acts specifically concerned with soil conservation;
- 2 There are soil-related legislative measures (such as the ones for erosion containment and the ones for environmental protection, improving biodiversity and landscape management or the ones for the Remediation of Contaminated Sites).

Belgium - BE

- 1 **Belgium has adopted some direct** measures for soil protection relating to agricultural activity (e.g. CAP or Federal states Code);
- 2 Federal states promote an integrated approach to improving water quality taking into consideration the soil quality, and, in particular, acting against soil sealing;
- 3 There are urban planning instruments that act at the federal level to govern land use changes.

Bulgaria - BG

- 1 Soil protection is addressed at the national level with programming and monitoring tools such as the national Law for land remediation of contaminated sites, agricultural productivity and the removal and reuse of topsoil or the Soil Act, the Law to prevent soil degradation

and its damage (the ecosystem approach).

Croatia - HR

1

1 Croatia has adopted a national Law aimed at managing the natural areas with soil protection from water and wind erosion. The law includes the regulation on the protection of the water cycle.

Cyprus - CY

1

1 The National Action Plan to Combat Desertification introduced policies and measures to prevent the desertification and to promote the sustainable use of soil and water. Additionally, the drought Management Plan is indirectly involved in soil management and acts against the salinization process.

Czech Republic - CZ

1

1 The Czech Republic introduced – in connection with CAP measures - regulations on agricultural practices such as the Law 156 of 1998 concerning the use of fertilizers. Law 262 of 2012, on the other hand, identifies the zones affected by nutrients;
2 Other national regulations are the Nature Protection Act 114 of 1992 and Water Act no. 254 of 2001 (to increase biodiversity) as well as the laws for agricultural soil protection including national Law no. 334 of 1992.

Denmark - DK

1

1 Agricultural practice is governed by a specific national Act on Tax on Pesticides and direct regulatory tools connected with the introduction of more sustainable agricultural practices (e.g., Sewage sludge, husbandry). Other measures on soil protection are linked to the instrument of the CAP (GAEC Cross-compliance Standards and greening) to guarantee protection and carbon stock conservation;

Estonia - EE

1

1 Estonia has two national programmes: The national Land Improvement Act, which outlines some rules for projecting, constructing and acting to increase the environmental conditions of soil; and the National Environmental Monitoring Programme which is mainly concerned with water and air quality as well as wildlife trends;
2 In 2015, a regional programme was instituted to support biological agricultural practices, which has been associated with the CAP 2014–2020.
3 Some indirect tools aimed at governing soil threats such as the Planning Act of 2015 and the Environmental Impact Assessment and Environmental Management System Act of 2005.

Finland - FI

1

1 In Finland, there are regulatory instruments at national level with specific goals for protection, such as the Government Development Programme for the Organic Product Sector and Objectives to 2020, or the Government Resolution on the Sustainable and Responsible Use and Conservation of Mires and Peatlands in force since 30/08/2012 for the protection of mires and peatlands;

2 The prevention of the risk of contamination is addressed by regulatory instruments such as the recent Decree on the Assessment of Soil Contamination and Remediation Needs (214/2017);
3 Soil compaction has been addressed by Finland through a national programme called “Soil Remediation under State Waste Management System”, while contamination is regulated by “Soil Remediation under State Waste Management System”.

France - FR

1 France adopted the fiscal and regulatory measures associated with CAP that indirectly address the issue of soil protection;
2 Four national codes preserve the soil in relation to urban planning, environment, agricultural practice, forestry, and fishing.

Germany - DE

1 Germany has five national Acts that address the soil issue: The Federal Soil Protection Act, in force since 1998 and recently modified (2015); the Building code re-enacted in 2004; the Fertilizer Act which was introduced in 1962; the Law on research and extraction of mineral resources, in force since 1980, and the Federal emission control Act (in force since 1974) that connects the presence of air pollution with its effect on Soil;
2 It also has several monitoring programmes

Greece - EL

1 A national legislative proposal for soil protection and its sustainable use is still under discussion;
2 At the national level, the Law for the protection of the environment no. 1650 has been in place since 1986 and there is the national action plan for combating desertification (adopted in 2002).

Hungary - HU

1 Two national acts regulate agricultural soils: the national Law to regulate the agricultural practices of 1994 and the Fourth National Environmental Remediation Programme which was introduced in 1997.

Ireland – IE

1 In 2002, Ireland put forward a proposal for a national Strategy to protect soil;
2 At national level, there is a strategy to protect and manage the wetlands and the peatlands;
3 Additional national laws include the Nitrates Regulations (2006) which fixes the maximum quantity of phosphorous from animal manure (170 kg/ha/year) and the natural forestry programme.

Italy – IT

1 Italy regulates soil protection mainly with four national acts: the Decree on Sewage Sludge of 1992 that regulates the use of sewage sludge in agriculture; the Decree on Regional Waste Management Plans of 2006; the Protocol of Soil Conservation of the Alpine Convention of 1998 and the Legislative Decree on Orientation and Modernization of the Forestry Sector of 2001;
2 Above all, there is the Environmental Code of 2006 that sets the regulatory framework for any environmental issues including soil protection.

Latvia – LV

1 Latvia has specific rules to control agricultural activity and avoid

- soil contamination such as the Regulation of Use, Monitoring and Control of Sewage Sludge and its Composts, the Regulation Regarding Protection of Water and Soil from Pollution with Nitrates caused by Agricultural Activity and a specific regulation for the control and management of the contamination, in force since 2010;
- 2 In relation to planning, Latvia adopted the General Regulation for the Planning, Use and Building of the Territory in 2013.

Lithuania – LT

- 1 Lithuania has adopted many national laws that directly address soil protection such as the Law on Environmental Impact Assessment, in force since 1996 and updated in 2013; the Regulations on Contaminated Sites Treatment Procedures; the Law on protected areas, in force since 1993 with the aims of preserving ecosystems and promoting ecological farming and, lastly the Law on forests to regulate reforestation, forest protection and forest use since 1994.

Luxembourg - LU

- 1 Various national acts address soil protection such as the regulatory measures introduced in 2000 for the use of Nitrogen Fertilizers in Agriculture and for the use of sewage sludge in agriculture to prevent contamination of soil and water. The loss of biodiversity is included in the Law on water of 2008 aimed at reducing the contamination of water bodies while the Law on waste management of 2012 has protection objectives and considers the contaminated Soil as “waste”;
- 2 In the field of planning and its effects, Luxembourg adopted the Law Concerning the Evaluation of the Environmental Impacts of Certain Plans and Programmes” and the Master Programme for Spatial Planning, in force since 2003, that outline measures for the long term safeguarding of the natural environment.

Malta - MT

- 1 Malta has adopted three national acts for soil protection: the National Environment Policy, in force since 2002, the Strategic Plan for Environment and Development of 2015 and the Nitrates Action Programme Malta, in force since 2011, that includes a limitation in the application of fertilizers on land, and Sludge.

Netherlands - NL

- 1 The Netherlands have adopted many national acts. The Soil Protection Act is the national framework for soil quality protection; the Soil Quality Decree of 2008 which aims to guarantee a balance between economic and social purposes with soil protection; compaction and the loss of biodiversity are addressed through the Erosion regulation; soil contamination is mainly addressed by the Water Act.

Poland - PL

- 1 Agricultural activity is regulated by the Code of good agricultural practices of 2004;
- 2 Two other national acts regulate soil threats: the law on forests, in force since 1991, with the aim of protecting the forest, their soils and ecosystem services and the Act on Preventing and Remedying Damage to the Environment which was adopted in 2007

Portugal - PT

- 1 Portugal has adopted a number of regulatory measures: the law on the Use of Sewage Sludge on Agricultural soils, in force since

2009; the law on the Distribution, Sale, and Application of Plant Protection Products for Professional Use; and the Manual of Agricultural Good Practices, adopted in 2009, dedicated to soil and water conservation;

- 2 Water contamination measures are included in The Water Law and the issue of soil, in general, is addressed by the Environment policy Act.

Romania - RO

- 1 Romania has adopted a number of regulatory measures including: the Decision on the Assessment of the Effects of Certain Public and Private Projects on the Environment which also includes the contents of the Environmental Impact Assessment (EIA); the Law on Afforestation of Degraded Land is aimed at soil protection and reclamation; contamination and degradation is also regulated by specific instruments such as the Law on Land Reclamation or the Ordinance on Environmental Liability.

Slovakia - SK

- 1 Slovakia has adopted several national measures such as the national Soil Protection Act of 2004. Soil contamination measures are mainly focused on agricultural activities and on the regulation of chemical substances and their use and the law on soil and water remediation.

Slovenia - SI

- 1 The protection of soil is mainly regulated through Acts on agricultural activities and the use of sewage sludge and nitrates;
- 2 Agricultural practices are regulated by the Land Act, in force since 1996;
- 3 Degradation caused by erosion or landslides is addressed by the Water Act and Delegated Regulations for Erosion, Flooding and Landslides. A Decree on the status of the soil was recently set out.

Spain - ES

- 1 In Spain, Soil is regulated by: the Royal Decree 1416/2006 to Decommission Petroleum-Product Tanks; the Decree on Protecting Waters from the Pollution by Nitrates Derived from Agricultural Sources; and the State Framework Plan for Waste Management 2016;
- 2 The Law for Integrated Pollution Prevention and Control establishes the procedures and limits for environmental emissions (covering air, Soil and water) for industrial operations, while the protection of soils from wind erosion and landslides/flooding is addressed mainly by instruments concerned with forests and their management such as the Forestry Law.

Sweden - ES

- 1 Soil protection is governed by the Strategy for Sustainable Land Use - not yet completed – in which is soil’s importance as a carbon sink in the reduction of Greenhouse gas (GHG) emissions is highlighted.

United Kingdom – UK

- 1 Soil protection (decline in soil organic matter and the landslides phenomenon) is addressed at the national level by the UK Forestry standard.
- 2 The state of soils is monitored through the Countryside survey which collects data on environmental- issues to support policy-makers.
- 3 Biodiversity protection is regulated at national level by the Agricultural Land (Removal of Surface Soil) Act, the Nitrate

Pollution Prevention Regulations, the Pesticides Control Legislation or the Sludge (Use in Agriculture) Regulations.

Results displayed in Table 2 show how each MS has adopted an autonomous legislative framework, revealing that their approaches lack homogeneity and coherence. When populations of different countries are affected by serious threats which are largely the same, each country will tend to respond in a different way, leading to a lack of coherence in approach.

Some important aspects of this study are reported below:

- Most of the soil protection policies and measures among the MS are directly linked to EU legislation (e.g. CAP or Act relating to the use of nitrates) that are mandatory and require binding instruments. There are fewer policies instigated at national level with non-binding measures, unconnected to EU legislation;
- EU binding policy initiatives do not cover all soil threats but an improved use of existing legislation, or legislation contained in upcoming EU policy dossiers, could have a strong impact on protection. For example, the definition of soil protection standards, promoted by CAP, could help to ensure more effective protection, particularly of SOM.
- The policies and direct measures on soil protection in the large majority of States refer to agricultural land, which is threatened by the intensification of agriculture and the maximization of harvests and yields. This will lead to an increasing degradation of agricultural soils, causing a decline in organic matter, soil compaction, salinization and loss of biodiversity as well as erosion or diffuse pollution;
- Sustainable management of agricultural soils in the EU is largely conditioned by the Common Agricultural Policy and its application by MS. The new CAP as proposed by the European Commission in 2018 will place a strong focus on the need to include soil protection and sustainable soil management at all levels. MS will have the opportunity to include sustainable soil management as a guiding principle in developing their national strategic plans following the adoption of the new CAP. The FAO Voluntary Guidelines for Sustainable Soil Management provide a clear framework for effectively implementing these positive soil protection measures;
- In most cases non-agricultural soil is only considered as a forestry resource and, in a few cases, it is managed by the Natural Capital and Ecosystem Services;
- The tools and measures to protect soil are largely only binding and regulatory when a taxation system is introduced which corresponds, according to the majority of the analysed cases, to a restoration of damages (degradation) rather than to subsidies or land use fees applied to discourage land use transformation on soils of primary quality;
- National laws on soil protection are not coordinated among themselves. Each country defines its own specific threats and there is no common definition or agreement on what is considered a threat. In most cases, threats are related to agricultural uses or, in some specific cases, determined by the orographic condition of the territory;
- The threats related to land take and soil sealing have recently been included in national policies even if the most substantial type of degradation, connected to land use change, is the process of urbanization. Few national governments have adopted a strategy for controlling urbanization, sprawl, land take or land use changes, while land use planning activity is governed at local level and requires stronger European regulation. The target of “no net land take by 2050” (European Commission, 2016) is only a roadmap that follows the “Soil sealing guidelines” (European Commission, 2012a) without binding measures. Few countries have adopted fiscal measures to dissuade urbanization on greenfield sites and the ones that have adopted land take measures are flattened regulatory approach that fixes the thresholds for urban expansion (with little likelihood

of achieving the target);

- In the majority of countries, there are tools and instruments to monitor land uses and land use changes at national and regional level with good support for the decision-making processes in regional government policies. Furthermore, the land use classification and the geometrical precision of land use datasets and their reliability, are nowadays reached following considerable effort and investment in land use and land cover monitoring programmes at European level such as CORINE Land Cover, LUCAS - Land Use/Land Cover Area Frame Survey;
- The way similar threats are managed among different countries varies widely. This affects the possible coordination of MS to find the right policy for a specific threat;
- The connection between soil quality and human health is weak and not addressed by national policies. Only a few cases demonstrate real attention to the link.

4.2. Policy suggestions

Overall, it is evident that a gap exists/evident that there is a persistent gap between the level of knowledge about soil degradation phenomena documented by monitoring data and the degree of policy attention given to the issue of soil degradation. In the recent years, the monitoring tools have managed to achieve great accuracy and reliability, both in terms of classification and precision. For example, CORINE Land Cover programme provided real knowledge about land use monitoring and the governance of land use transformation. Another example is or how LUCAS which has restarted the development of soil indicators in the EU that are now compiling new data and improving the assessment of soil threats and soil functions).

LUCAS Soil provides data from three surveys (2009–2012, 2015 and 2018) and is the largest harmonized open-access dataset of topsoil properties on a global scale. The LUCAS monitoring system provides the data for policy-relevant indicators on the impact of land management practices on soil properties, facilitating decisions in relation to the implementation of soil related policies, such as, for example, the CAP or policies relating to climate change (Keesstra et al., 2016; Orgiazzi et al., 2018). Ancillary databases also provide soil-related material such as geological information relevant to the assessment of some aspects of soil quality (see Land Capability Classification). Nevertheless, even if soil-related issues are well documented by many datasets, existing policies relating to soil are still largely disconnected from the body of evidence provided by these various sources of information and data.

The risk is that, even if the scientific evidence is strong, the impact on policy development remains weak, or in the worst case, completely absent. In any case, the policy framework remains dis-homogeneous, leading to huge and evident disparity in soil protection among MS.

The recent assessment of ecosystem services (ES) and nature's contribution to people (NCP) relating to land degradation and restoration (IPBES, 2018) directed attention towards the importance of soil functions and the benefits and services that they provide to the population as a whole. Nonetheless, the debate still remains confined to the academic community, whereas it is vital that the general public and the major stakeholders become involved and help in shaping a new political agenda towards soil protection.

There is a need to launch a new legislative initiative in order to achieve a binding legal framework at EU level protecting soils for future generations.

The reasons are many:

- 1 Soil degradation has transboundary consequences: sediments and nutrients can flow through bordering nations. Pollution and contamination are cross-border phenomena too, with the risk of severe market distortions in the case of diverging legislations on contaminated site management and remediation obligations. The loss of soil organic matter and its consequences on a global scale, due to

increased GHG emissions, is a major additional transboundary effect of soil degradation.

- 2 Soil degradation impacts other natural resources already governed by an existing EU legislation (e.g. water, nature, biodiversity, climate change). A legislative instrument on soil protection would increase the possibility of achieving effective environmental protection (including food security and agricultural productivity through the CAP).
- 3 Common legislation, based upon a coherent framework, will benefit the Community providing improved knowledge on soil, increasing the local know-how and developing more efficient technical assistance.

A common approach for EU legislation will prompt an efficient use of the national capabilities achieving environmental, economic and social benefits which significantly outweigh the costs of the initiative.

The framework should also be a fundamental tool in achieving the aims posed by the Sustainable Development Goals (SDG) of the United Nations. Among the 17 Goals, soil plays a vital role in achieving many targets: reduce poverty (Goal 1), achieve food security (Goal 2), increase human health (Goal 3), achieve sustainability in cities (Goal 11), reach sustainable consumption and production (Goal 12), combat climate change (Goal 13) and augment biodiversity (Goal 15). The last goal in particular (Goal 15) refers to soil-related threats (biodiversity, desertification, deforestation) and presents specific targets that require a legislative intervention:

- 1 “By 2030, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements;
- 2 By 2030, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts” (United Nations, 2015).

Other avenues for achieving effective soil protection in the EU include increasing the integration of sustainable soil management measures within existing EU legislative instruments, like the CAP. The strong emphasis in the new CAP on soil protection measures that can be adopted by the MS could be the best way forward. However, the actual impact on soil resources will require close monitoring and verification in order to report any substantial improvement of soil conditions in the EU. Nevertheless, even if all MS reported the regulation of agricultural activities in the framework of the CAP, it would still be insufficient in achieving effective soil protection at an EU level encompassing all threats, including soil contamination and soil sealing. A new paradigm is needed, based on new evidence provided by a new assessment of land degradation and restoration of the closed links between soil functions and ecosystem services (IPBES, 2018). Only few MS consider ecosystem services in relation to soil protection legislation. There is a large body of evidence underpinning the need to link ecosystem services with soil protection, as was recently documented and demonstrated by the soil pilot study within the Mapping of Ecosystem Services (MAES) programme of the EU. The pilots within MAES demonstrate the need for protection, management and restoration of soil ecosystems looking at six ecosystem types: 1) Forest ecosystems, 2) Cropland and grassland ecosystems, 3) Freshwater ecosystems, 4) Marine ecosystems, 5) Urban ecosystems and 6) Soil ecosystems. Pilots harmonize measures and indicators used to assess ecosystem services at different levels (from national to local). MS should pay more attention to this document as ecosystem services can be seen as the *trade d'union* between knowledge about soil and soil protection legislation.

5. Conclusion

There is extensive evidence of severe ongoing soil degradation

processes in all EU MS. The type of degradation varies greatly depending on the pedo-climatic as well as the socio-economic situation of each of the countries concerned. Specific threats to soil functions are typical of certain areas of Europe, like droughts and desertification in the Mediterranean countries, or peatland drainage and degradation in Northern and Scandinavian countries. Soils in Europe are generally under threat and, since they can be considered as a non-renewable resource, at least within a human generation, they need to be protected for future generations in order to achieve more sustainable development. Most EU MS have developed and implemented some form of national legislation which addresses specific soil related issues relevant to soil protection.

Nevertheless, the gap analysis has highlighted how a binding legal instrument can have a strong impact on soil protection and how the lack of a coherent approach to soil protection and sustainable soil management has limited the effectiveness of EU wide soil conservation efforts.

In the absence of a common regulatory framework on soil, different EU initiatives have developed voluntary instruments that can be applied by MS at their discretion. An example is represented by the Voluntary Guidelines for Sustainable Soil Management (VGSSM), endorsed by the 155th session of the FAO Council in 2016, which provide “guidelines to address technical aspects of SSM including core characteristics of sustainably managed soils, key challenges and potential solutions to address them” (FAO, 2016).

Moreover, extensive cross-compliance measures have been introduced within the CAP which address some of the agricultural soil degradation processes, like erosion and soil organic matter loss. However, such EU wide measures are still of a sectoral nature and only partially address the problem of soils as the basis for sustainable development.

Another important step forward in recognition of and progress towards soil protection is the 7th Environment Action Programme (7th EAP) promoted by Decision no. 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 in a General Union Environment Action Programme to 2020 “Living well, within the limits of our planet” (European Union, 2013). The programme promotes actions for the implementation of current, sectoral EU legislation examining a binding legal framework on soil. Most of the soil threats are covered by the programme even if its non-binding nature limits its strength and operability.

The adoption in 2015 of the new Sustainable Development Goals (SDG), with the ambition of achieving to achieve at global level by 2030, some of the crucial soil related goals, such as eliminating hunger (SDG2), achieving food security and food safety (SDG3) for all and protecting the terrestrial environment (SDG15), may also bring about substantial improvements in the EU, since the SDGs are of a universal nature and should be fully implemented in the EU MS. Hopefully, in 2030, we will be able to report substantial progress on soil quality in the European Union through the available indicators and data.

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References

- Abdelrahman, M.A.E., Natarajan, A., Srinivasamurthy, C.A., Hegde, R., 2016. Estimating soil fertility status in physically degraded land using GIS and remote sensing techniques in Chamarajanagar district, Karnataka, India. *Egypt. J. Remote Sens. Sp. Sci.* 19, 95–108. <https://doi.org/10.1016/j.ejrs.2015.12.002>.
- Ballabio, C., Panagos, P., Lugato, E., Huang, J.H., Orgiazzi, A., Jones, A., Fernández-Ugalde, O., Borrelli, P., Montanarella, L., 2018. Copper distribution in European topsoils: an assessment based on LUCAS soil survey. *Sci. Total Environ.* 636, 282–298. <https://doi.org/10.1016/j.scitotenv.2018.04.268>.
- Blum, W.E.H., 2002. Environmental protection through sustainable soil management, a holistic approach. *Advances in Geocology, Sustainable Land Management – Environmental Protection – A Soil Physical Approach*. pp. 1–8.
- Blum, W.E.H., 2005. Functions of soil for society and the environment. *Rev. Environ. Sci. Biotechnol.* 4, 75–79. <https://doi.org/10.1007/s11157-005-2236-x>.
- Blum, W.E.H., 2008. Characterisation of soil degradation risk: an overview. *Threats to Soil Quality in Europe*. Office for Official Publications of the European Communities, Luxembourg, pp. 5–10. <https://doi.org/10.2788/8647>.
- Borrelli, P., Lugato, E., Montanarella, L., Panagos, P., 2017. A new assessment of soil loss due to wind erosion in European agricultural soils using a quantitative spatially distributed modelling approach. *L. Degrad. Dev.* 28, 335–344. <https://doi.org/10.1002/ldr.2588>.
- Breure, A., De Deyn, G., Dominati, E., Eglin, T., Hedlund, K., Van Orshoven, J., Posthuma, L., 2012. Ecosystem services: a useful concept for soil policy making! *Curr. Opin. Environ. Sustain.* 4, 578–585. <https://doi.org/10.1016/j.cosust.2012.10.010>.
- Commission of The European Communities, 1990. *Green Paper on The Urban Environment*. Distribution.
- Daliakopoulos, I.N., Tsanis, I.K., Koutroulis, A., Kourgiyalas, N.N., Varouchakis, A.E., Karatzas, G.P., Ritsema, C.J., 2016. The threat of soil salinity: a European scale review. *Sci. Total Environ.* 573, 727–739. <https://doi.org/10.1016/j.scitotenv.2016.08.177>.
- de Brogniez, D., Ballabio, C., Stevens, A., Jones, R.J.A., Montanarella, L., van Wesemael, B., 2015. A map of the topsoil organic carbon content of Europe generated by a generalized additive model. *Eur. J. Soil Sci.* 66, 121–134. <https://doi.org/10.1111/ejss.12193>.
- ELD Initiative, 2013. The rewards of investing in sustainable land management. *Interim Report for the Economics of Land Degradation Initiative: a global strategy for sustainable land management*. Framework 15, 1–124.
- European Commission, 2012a. *Guidelines on Best Practice to Limit, Mitigate or Compensate Soil Sealing*. Commission Staff Working Document. Publications Office of the European Union, Luxembourg. <https://doi.org/10.2779/75498>.
- European Commission, 2012b. *The Implementation of the Soil Thematic Strategy and Ongoing Activities*.
- European Commission, 2014. *Official Journal of the European Union C 163 Publication office of the European Union*, London.
- European Commission, 2015. *1st Meeting of the EU Expert Group on Soil Protection*.
- European Commission, 2016. *FUTURE BRIEF: No Net Land Take by 2050? Produced for the European Commission DG Environment by the Science Communication Unit, Bristol*. <https://doi.org/10.2779/537195>.
- European Commission, 2018. *Proposal for a Regulation of the European Parliament and of the Council Establishing Rules on Support for Strategic Plans to Be Drawn up by Member States Under the Common Agricultural Policy (CAP Strategic Plans) and Financed by the European Agricultural*.
- European Environment Agency, 2016. *Good Agricultural Environmental Conditions (GAEC 2010)*. WWW Document]. Data Maps. URL. <https://www.eea.europa.eu/data-and-maps/data/external/good-agricultural-environmental-conditions-gaec-2010>.
- European Union, 2013. *Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 “living well, within the limits of our planet*. *Off. J. Eur. Union* 171–200. <https://doi.org/10.2779/57220>.
- FAO, 2016. *Voluntary guidelines for sustainable soil management*. 155th Sess. FAO Council 15 5th December 2016.
- FAO and ITPS, 2015. *Status of the World's Soil Resources (Main Report)*. Fao [https://doi.org/ISBN 978-92-5-109004-6](https://doi.org/ISBN%20978-92-5-109004-6).
- FAO - Food, Agriculture Organization of the United Nations, 2013. *FAOI Soils Portal*. [WWW Document]. URL. <http://www.fao.org/soils-portal>.
- Freljh-Larsen, A., Bowyer, C., Albrecht, S., Keenleyside, C., Kemper, M., Nanni, S., Naumann, S., Mottershead, D., Landgrebe, R., Andersen, E., Banfi, P., Bell, S., Brémere, I., Cools, J., Herbert, S., Iles, A., Kampa, E., Kettunen, M., Lukacova, Z., Moreira, G., Kiresiewa, Z., Rouillard, J., Okx, J., Pantzar, M., Paquel, K., Pederson, R., Peepson, A., Pelsy, F., Petrovic, D., Psaila, E., Šarapatka, B., Sobocka, J., Stan, A., Tarpey, J., Vidaurre, R., 2017. *Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States - Final Report*. pp. 462.
- Gardi, C., Panagos, P., Van Liedekerke, M., Bosco, C., De Brogniez, D., 2015. *Land take and food security: assessment of land take on the agricultural production in Europe*. *J. Environ. Plan. Manag.* 58, 898–912. <https://doi.org/10.1080/09640568.2014.899490>.
- Glæsner, N., Helming, K., de Vries, W., 2014. Do current European policies prevent soil threats and support soil functions? *Sustain.* 6, 9538–9563. <https://doi.org/10.3390/su6129538>.
- Jeffery, S., Gardi, C., Jones, A., Montanarella, L., Marmo, L., Miko, L., Ritz, K., Peres, G.J.R., van der Putten, W.H., 2010. *European atlas of soil biodiversity*. *Off. Eur. Union*. [https://doi.org/10.1016/S0016-7061\(99\)00028-2](https://doi.org/10.1016/S0016-7061(99)00028-2).
- Jones, a, Panagos, P., Barcelo, S., Bouraoui, F., Commission, E., Ies, C., 2012. *The state of soil in Europe*. JRC Ref. report. Jt 80. <https://doi.org/10.2788/77361>.
- Keesstra, S.D., Bouma, J., Wallinga, J., Tittonell, P., Smith, P., Cerdà, A., Montanarella, L., Quinton, J.N., Pachepsky, Y., Van Der Putten, W.H., Bardgett, R.D., Moolenaar, S., Mol, G., Jansen, B., Fresco, L.O., 2016. The significance of soils and soil science towards realization of the United Nations sustainable development goals. *Soil* 2, 111–128. <https://doi.org/10.5194/soil-2-111-2016>.
- Lamandé, M., Greve, M.H., Schjønning, P., 2018. Risk assessment of soil compaction in Europe – rubber tracks or wheels on machinery. *Catena* 167, 353–362. <https://doi.org/10.1016/j.catena.2018.05.015>.
- Lugato, E., Panagos, P., Bampa, F., Jones, A., Montanarella, L., 2014. A new baseline of organic carbon stock in European agricultural soils using a modelling approach. *Glob. Chang. Biol.* 20, 313–326. <https://doi.org/10.1111/gcb.12292>.
- Nations, United, 1994. *Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa*.
- Orgiazzi, A., Panagos, P., Yigini, Y., Dunbar, M.B., Gardi, C., Montanarella, L., Ballabio, C., 2016. A knowledge-based approach to estimating the magnitude and spatial patterns of potential threats to soil biodiversity. *Sci. Total Environ.* 545–546, 11–20. <https://doi.org/10.1016/j.scitotenv.2015.12.092>.
- Orgiazzi, A., Ballabio, C., Panagos, P., Jones, A., Fernández-Ugalde, O., 2018. LUCAS Soil, the largest expandable soil dataset for Europe: a review. *Eur. J. Soil Sci.* 69, 140–153. <https://doi.org/10.1111/ejss.12499>.
- Paleari, S., 2017. Is the European Union protecting soil? A critical analysis of Community environmental policy and law. *Land Use Policy* 64, 163–173. <https://doi.org/10.1016/j.landusepol.2017.02.007>.
- Panagos, P., Hiederer, R., Van Liedekerke, M., Bampa, F., 2013. Contaminated sites in Europe: review of the current situation based on data collected through a european network. *J. Environ. Public Health* 1–11. <https://doi.org/10.1016/j.ecolind.2012.07.020>.
- Panagos, P., Borrelli, P., Poesen, J., Ballabio, C., Lugato, E., Meusburger, K., Montanarella, L., Alewell, C., 2015. The new assessment of soil loss by water erosion in Europe. *Environ. Sci. Policy* 54, 438–447. <https://doi.org/10.1016/j.envsci.2015.08.012>.
- Panagos, P., Imeson, A., Meusburger, K., Borrelli, P., Poesen, J., Alewell, C., 2016. Soil conservation in Europe: wish or reality? *L. Degrad. Dev.* 27, 1547–1551. <https://doi.org/10.1002/ldr.2538>.
- Panagos, P., Ballabio, C., Lugato, E., Jones, A., 2017. *Condition of Agricultural Soil: Factsheet on Soil Erosion Agricultural Soils*. <https://doi.org/10.2760/728794>.
- Pimentel, D., Whitecraft, M., Scott, Z.R., Zhao, L., Satkiewicz, P., Scott, T.J., Phillips, J., Szimák, D., Singh, G., Gonzalez, D.O., Moe, T.L., 2010. Will limited land, water and energy control human population numbers in the future? *Hum. Ecol.* 38, 599–611.
- Právělie, R., Patriche, C., Bandoc, G., 2017. Quantification of land degradation sensitivity areas in Southern and Central Southeastern Europe. New results based on improving DISMED methodology with new climate data. *Catena* 158, 309–320. <https://doi.org/10.1016/j.catena.2017.07.006>.
- Prokop, G., 2011. *Report on Best Practices for Limiting Soil Sealing and Mitigating Its Effects*. <https://doi.org/10.2779/15146>.
- Stolte, J., Tesfai, M., Keizer, J., Øygarden, L., Kværnø, S., Verheijen, F., Panagos, P., Ballabio, C., Hessel, R., 2015. *Soil Threats in Europe*. <https://doi.org/10.2788/828742>.
- United Nations, 1992. *Convention on Biological Diversity*. *Diversity* 30. <https://doi.org/10.1146/annurev.ento.48.091801.112645>.
- United Nations, 2015. *Sustainable Development Goals*. UN Web Serv. Sect. Dep. Public Information, United Nations WWW Document URL (accessed 6.5.18). <https://www.un.org/sustainabledevelopment/biodiversity>.
- Van-Camp, L., Bujarrabal, B., Gentile, A.R., Jones, R.J.a, Montanarella, L., Olazabal, C., Selvaradjou, S.-K., 2004. Reports of the technical working groups established under the thematic strategy for soil protection. *Management* 192. <https://doi.org/10.13140/RG.2.1.4281.9922>.
- Wilde, M., Günther, A., Reichenbach, P., Malet, J.-P., Hervás, J., 2018. Pan-European landslide susceptibility mapping: ELSUS Version 2. *J. Maps* 14, 97–104. <https://doi.org/10.1080/17445647.2018.1432511>.