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An overview of a land evaluation in the context of ecosystem services

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Abstract: The environment is changing quickly and it is ever more burdened in connection with the greater needs of human society. This fact has increased efforts to improve the management of land and natural resources and the necessity to evaluate them. Land valuations become more important as the land consumption increases. Soil needs to be evaluated in the whole context of how its quality is affected and the values it provides. The concept of ecosystem services offers this holistic view. This paper defines ecosystem services (ES), the various linkages between soil properties, their functions and benefits, the assessment of soil quality using indicators and then briefly mentions EU environmental assessment methods and terms used in the context of ES. The article also mentions frameworks with which to assess and evaluate the soil quality that can be divided into two groups. The first group is comprised of a framework of indicators that describe the current state of the soil system assessment for evaluating the quality of the agricultural land. This is based on a detailed measurement of the terrain, a statistical analysis of soil databases or processing the status of specific threats to the soil. The second group is comprised of a framework of indicators focused on changes in the soil quality and applied soil management. These frameworks deal with the productivity of the soil in various systems of farming, compare agricultural systems or discuss the advantages of soil biota as indicators of soil quality in detail. Many of the designs of the soil quality indicators focus on the soil management in the context of a single discipline such as agriculture or water pollution. There are concepts for considering the soil quality in regional planning.

Keywords: BOKS index; soil functions; soil quality; SQUID index; sustainable soil management

Soil conservation is a pressing challenge today and soil conservation is significantly related to the soil assessment. Financially undervalued agricultural land makes it easy to speculate on land and convert it into land for

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construction, where the market value is usually many times higher. There is a need to set up the sustainable management of natural resources and to take a holistic approach to land decisions (Herrick 2000; McBratney et al. 2014). Sustainable soil management is reflected in the health, quality and development of the soil (Doran & Zeiss 2000). A proper land valuation, therefore, helps to protect it. Land is both real estate and a natural resource, and this fact complicates the land value assessment. This is where natural and social components meet. An important development in this respect is the valuation in the context of ecosystem services.

Influencing soil quality and evaluation of soil functions

In all cases, the assessment is a determination of the soil quality. Doran and Parkin (1994) proposed a definition of soil quality (SQ), which is understood as the ability of a soil to function within the boundaries of an ecosystem and maintain its productivity, provide environmental quality and support healthy plant and animal development. The SQ is the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health (Doran et al. 1996; Karlen et al. 1997). The soil quality is the degree to which a soil can perform its soil functions. A soil with a ‘high soil quality’ can deliver the desired functions to meet demands, whereas a soil with a ‘low soil quality’ delivers functions at suboptimal levels (Landmark Glossary 2020).

The terms soil quality and soil health are often used interchangeably. However, use of the term soil quality will generally be associated with a soil’s fitness for a specific use and the term soil health is used in a broader sense to indicate the capacity of a soil to function as a vital living system to sustain biological productivity, promote environmental quality, and maintain plant and animal health. In this sense, soil health is synonymous with sustainability.

To accentuate this difference, soil quality has been redefined as a measure of the condition of a soil relative to the requirements of one or more biological species and/or to any human purpose (Johnson et al. 1997), and it is recommended that the soil quality should be evaluated based on the soil function (Doran et al. 1996).

Soil health is the actual capacity of a particular soil to function, contributing to ecosystem services (Bouma 2014).

According to Dominati et al. (2010), who analysed soils as stocks with a focus on their sustainable capacity, soils have different types of characteristics. Some of them can be influenced by human activities, while others cannot. For example, the landscape slope, soil depth, cation exchange capacity and clay types can hardly be influenced by humans and are, thus, “soil-inherent”, while the soluble phosphate, mineral nitrogen, organic matter content, and others are shaped by human management practices and are, thus, called “soil-manageable properties”.

Similarly, Vogel et al. (2018) argue for a focus on “functional soil characteristics”, which are a result of internal soil processes and interactions. Contrarily, “inherent soil properties” represent rather stable soil formation characteristics and “soil state variables”, which change and are relevant for management.

The soil’s actual capacity to provide and sustain functions can be hampered by a number of degradation processes (Tóth et al. 2008; Schjønning et al. 2009), identified as soil threats in the European Soil Thematic Strategy (CEC 2006). The American Soil Science Society has defined this as “the capacity of a soil type to function within natural or managed ecosystem boundaries”. The concept of soil function assessment emphasises the multifunctionality of soils (Greiner et al. 2017; Drobnik et al. 2018).

The function is invariably used as a synonym for the process, functioning, role, and service (Glenk et al. 2012; Baveye et al. 2016). According to Bünemann et al. (2018), we define soil functions as (bundles of) soil processes that underpin the delivery of ecosystem services.

Evidently, agricultural soils provide human society with the production of food, fibre, and energy. In a broader sense, soils fulfil all kinds of natural functions that sustain life through supporting primary production and decomposition processes, regulating nutrient, carbon and water cycles and controlling multiple ecosystem processes, such as buffering, filtering, storage, and providing a habitat for organisms. To characterise this essential multifunctionality of a soil, the concept of SQ was developed (Karlen et al. 1997) to provide a rationale for the evaluation and sustainable use of soils.

A soil is essentially a non-renewable resource, a very dynamic system which performs many functions and delivers services vital to human activities and to the survival of ecosystems. These functions are biomass production, storing, filtering and transforming nutrients and water, hosting the biodiversity pool, acting as a platform for most human activities, providing raw materials, acting as a carbon pool and storing geological and archaeological heritage (CEC 2006).

Soil functions refer to soil-based ecosystem services: an overarching concept referring to aspects of the soil system that contribute to the generation of goods and services (Haygarth & Ritz 2009; Bouma et al. 2012; Rutgers et al. 2012; Schulte et al. 2014).

The Landmark Glossary (2020) developed a comprehensive science-based framework for understanding and quantifying soil functions (Figure 1).

Ecosystem services

The environment is changing rapidly and is increasingly burdened by the greater needs of human society. Awareness of this fact has helped to define ecosystem services and raise interest in them. Ecosystem services are essential for survival as well as for social and economic development. These are goods and services provided by nature to meet basic human needs (MA 2005).

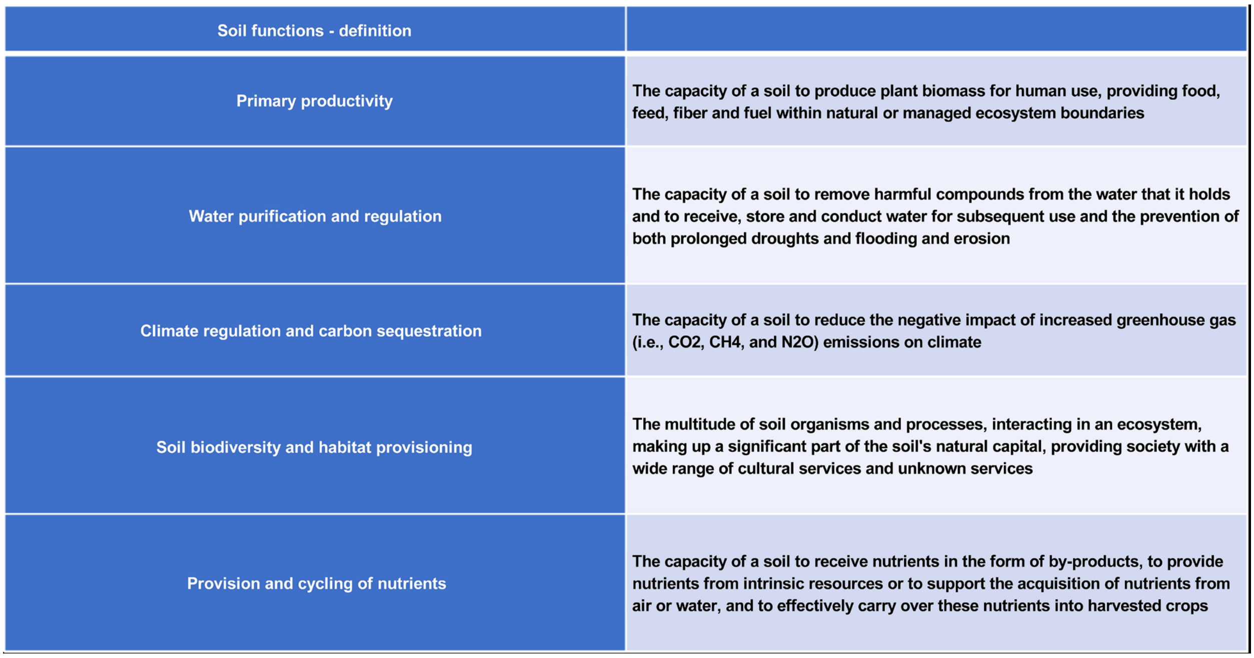
IPBES (Inter-governmental Science-Policy Platform on Biodiversity and Ecosystem Services) defines them as natural contributions to people.

By behaving responsibly towards the landscape, nature provides so-called ecosystem services. These are the benefits that ecosystems are capable of delivering to society (Haines-Young & Potschin-Young 2010). Costanza et al. (1997) describes ecosystem services as the flow of materials, energy and information from natural resources that create human well-being. The evaluation of ecosystem services contributes substantially to the development of knowledge about the state of the environment and the sustainable management of natural capital.

Assessing and evaluating ecosystem services is a way to help simplify decisions about using the landscape. The Economics of Ecosystems and Biodiversity (TEEB) (2010) study distinguishes several purposes of evaluating ecosystem services.

(1) Visualising nature's value. The evaluation of ecosystem services contributes to informing the role of biodiversity and ecosystem services in the economy and society. The disregard for ecosystem services has, in many cases, led to their disruption, with consequences to the quality of life of humans.

(2) The evaluation of ecosystem services and their inclusion in decision making. Although the economic evaluation of ecosystem services may be controversial, a variety of methods are currently available to enable the valuation of natural goods and services. The best available information should be used to assess the benefits and costs of protecting or restoring ecosystems and their use in decision making, although it will require a further specification of assessment standards and principles for evaluation at a local level.



Soil functions - definition	
Primary productivity	The capacity of a soil to produce plant biomass for human use, providing food, feed, fiber and fuel within natural or managed ecosystem boundaries
Water purification and regulation	The capacity of a soil to remove harmful compounds from the water that it holds and to receive, store and conduct water for subsequent use and the prevention of both prolonged droughts and flooding and erosion
Climate regulation and carbon sequestration	The capacity of a soil to reduce the negative impact of increased greenhouse gas (i.e., CO2, CH4, and N2O) emissions on climate
Soil biodiversity and habitat provisioning	The multitude of soil organisms and processes, interacting in an ecosystem, making up a significant part of the soil's natural capital, providing society with a wide range of cultural services and unknown services
Provision and cycling of nutrients	The capacity of a soil to receive nutrients in the form of by-products, to provide nutrients from intrinsic resources or to support the acquisition of nutrients from air or water, and to effectively carry over these nutrients into harvested crops

Figure 1. Framework for understanding and quantifying soil functions (Landmark Glossary 2020)

https://doi.org/10.17221/136/2021-SWR

(3) Reducing risk and uncertainty. Biodiversity contributes to the resilience of ecosystems and provides a safety measure to ensure services under changing environmental conditions. Approaches, such as setting safe minimum standards or adopting the precautionary principle, can be used to assess risk.

(4) Value for the future. The current governance of ecosystem services affects future generations. The evaluation of ecosystem services provides evidence for a benefit-cost analysis, taking different development scenarios and different natural capital discount rates into account.

(5) Measurement for management. Investing in biodiversity indicators and ecosystem services, their mapping and evaluation, and developing national accounts that take the role and value of nature into account lead to the better management and management of nature services.

Understanding how different ecosystems (forests, wetlands, rivers, meadows, pastures, etc.) contribute to social and economic benefits is essential to ensure the long-term conservation of biodiversity and the sustainable use of ecosystems. In the European Union, the MAES (Mapping and Assessment of Ecosystem Services) process has introduced a conceptual framework linking biodiversity, the ecosystem condition and ecosystem services to the well-being of humans (Veidemane 2019). The flow of ecosystem services is seen as a link between socio-economic systems and MAES ecosystems. Processes and functions occur within the ecosystem and are influenced by anthropic factors that can have positive or negative impacts on the provision of services. Biodiversity plays a key role in the structural arrangement of ecosystems, which is necessary to maintain essential ecosystem processes and support ecosystem functions.

Figure 2 shows a diagram of the conceptual framework for the ecosystem assessment in the European Union.

The assessment of ecosystem services and a trade-off analysis provide new insights into the spatial planning and decision-making at different administrative and spatial levels and in different sectoral policies. European and national policies should take the benefits provided by the concerned ecosystems into account and ensure that greater weight is given to the importance of ecosystem services in policy implementation (Veidemane 2019).

Benefits, such as protection against erosion on slopes, protection against flooding, availability of groundwater and surface water, fertile land for agriculture and much more, can be imagined under ecosystem services (Daily 1997; Boyd & Banzhaf 2007; Haines-Young & Potschin-Young 2010). According to the Millennium Ecosystem Assessment (MA 2005), ecosystem services are divided into four categories that provide some benefits to society. These categories include supply services (food production, natural compounds, fuel, and other biological materials, etc.), regulatory (climate control, protection from natural disasters, diseases, water purification, etc.), support/biotope (water cycle, plant production, nutrient cycle, etc.) and cultural (aesthetics,

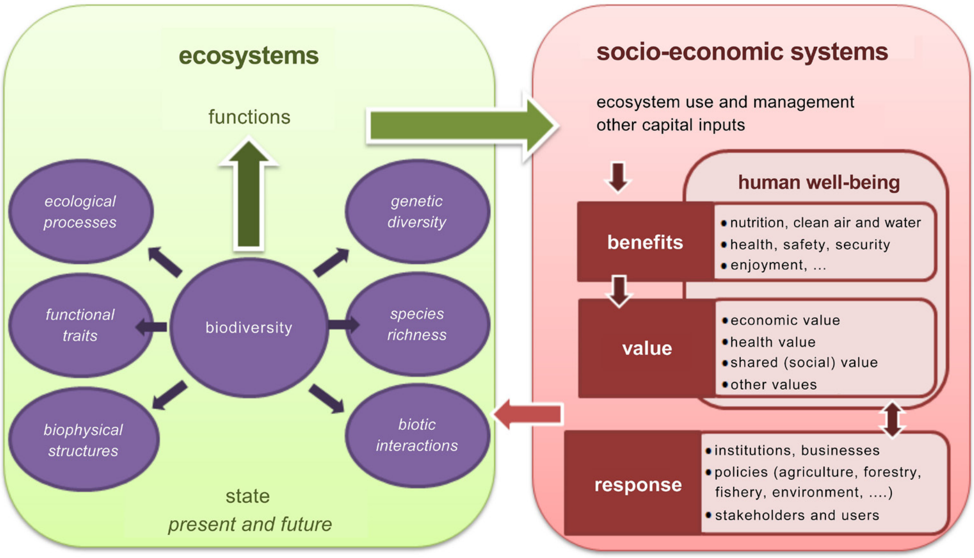


Figure 2. Conceptual framework for EU-wide ecosystem assessments (Maes et al. 2013)

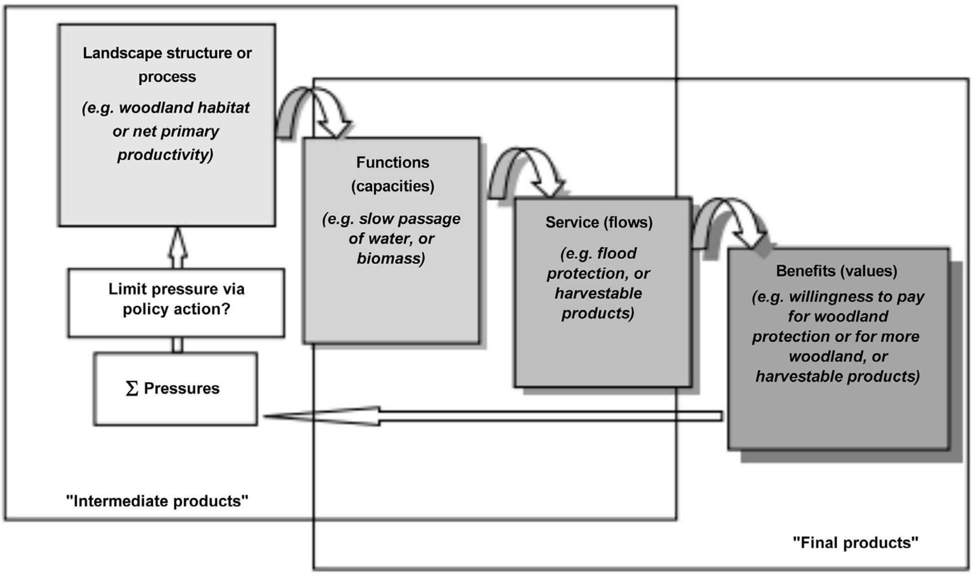


Figure 3. The relationship between biodiversity, ecosystem function and human well-being (Haines-Young & Potschin-Young 2010)

recreational or educational environments, etc.). Similarly, ecosystem services are divided into three categories (production, regulation and maintenance, cultural function) (Veidemane 2019).

Unfortunately, many benefits are still neglected since their value is very difficult to quantify in terms of finance (Bastian et al. 2012).

The production of ecosystem goods and services reflects the presence and state of ecosystems in the landscape (Kienast et al. 2009; Haines-Young & Potschin-Young 2010). This dependence is most often illustrated by an ecosystem cascade (Figure 3). The beginning of the cascade depicts elements of the biotic and abiotic environments whose physical presence and arrangement in the landscape are essential for ecosystem functions, the mechanisms that generate ecosystem services.

There are three interlinked concepts related to the provision of ecosystem services. These are the ecosystem process, ecosystem function and ecosystem service. The ecosystem process refers to any change or reaction (biological, physical or chemical) that occurs in ecosystems. Ecosystem processes include decomposition, production, nutrient cycling, and nutrient energy flows (MA 2005). The second concept relates to the ecosystem function. This is the so-called subset of interactions between biophysical structures, biodiversity and ecosystem processes that support the ability of the ecosystem to provide ecosystem services. The third concept is ecosystem services (TEEB 2010).

The functional process that is carried out by the soil ecosystem contributes to a range of ecosystem services that are essential for the sustainability of human society. These services include element cycling and nutrient supply, energy supply, natural pollutant buffering capabilities, etc. With the intensive increase of anthropogenic activity, soil ecosystems are susceptible to contamination by a mixture of hazardous elements and chemicals that are likely to affect the ecological functions, services and sustainability of the soil ecosystem (Jiang et al. 2019).

Land use change, for example, from pasture to arable land, also results in new landscape structures (e.g., hedgerows, pathways) and in a modified (altered, degraded, reduced, neutral or enhanced) ability of the location or landscape to provide ecosystem services. An example of ecosystem service linkages may be the intensive use of agricultural land. Although it produces food for humanity, this activity also most often causes problems with the water quality and quantity in the watershed and loss of biodiversity (Veidemane 2019).

For ecosystem services, it is also an important form of property rights that affect the soil functions as well.

Given the increasing scarcity of soils (Gomiero 2016; Nkonya et. al. 2016), the definition of property rights for soils appears highly important. Relevant actions related to the land and soils are (Schlager & Ostrom 1992; Vatn 2016) the access, withdrawal (enjoyment of the “fruits” provided by the land/soils),

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management, exclusion (preventing others from access, withdrawal, and/or management), alienation (transferring the land to another person or entity (by selling or giving away)).

The ecosystem service approach (TEEB 2010; Díaz et al. 2015) aims at integrating natural and social systems, providing a more comprehensive approach for decision-making and management.

Functional Land Management is a conceptual framework for optimising the supply of soil-based ecosystem services (Schulte et al. 2014).

Soil functionality depends on the soil type "S" (i.e., diagnostic features – intrinsic and dynamic ones), the environment "E" (climate, weather, slope, land use, etc.) and the soil management "M" acknowledging that soil functions are never uniquely determined by just one of these three factors, S × E × M (Schulte et al. 2014).

Ecosystem services (ES) have, by definition, an anthropocentric focus: ES are the direct or indirect contributions from ecosystems to human welfare and something can be considered as an ecosystem service if direct or indirect human demand and beneficiaries can be identified (Haines-Young & Potschin 2013). As central components of ecosystems, soils are essential in the provision of ecosystem services (Figure 4) and although ES associated with soils are numerous (Adhikari & Hartemink 2016; Grêt-Regamey et al. 2016; Keesstra et al. 2016; Pereira et al. 2018), it should be acknowledged that soils do not produce ES independently from the functioning of the whole ecosystem (Bouma 2014).

The soil ecosystem structure and the associated processes can be seen in mutual association to represent the soil quality, as the current capacity of a soil to function as a vital living system, within an ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality and promote plant and animal health (Doran et al. 1996; Karlen et al. 1997). Natural and anthropogenic factors can directly or indirectly cause change in agricultural production systems, inducing changes in management system by farmers and other actors in the agricultural landscape (e.g., water boards, conservation managers) affecting the soil ecosystem functioning. Hence, the SQ and subsequent ES provision should be implemented into an integrated soil policy and land management system and, thus, it is appropriate to integrate the Driving forces, Pressure, State, Impact, Response (DPSIR) and ES approaches into one framework (Figure 5).

The DPSIR concept (Smeets & Weterings 1999), especially the DPSWR framework (Driver, Pressure, State

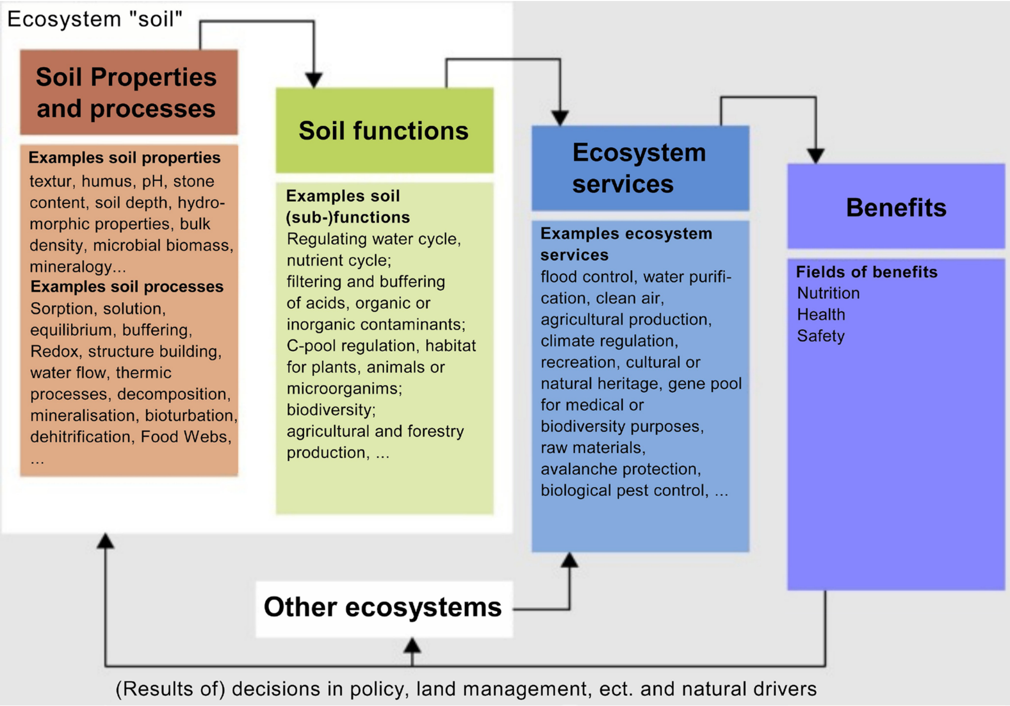

Figure 4. Assessment of the contributions of soil functions to ecosystem services using the cascading framework developed by Haines-Young and Potschin-Young (2008)

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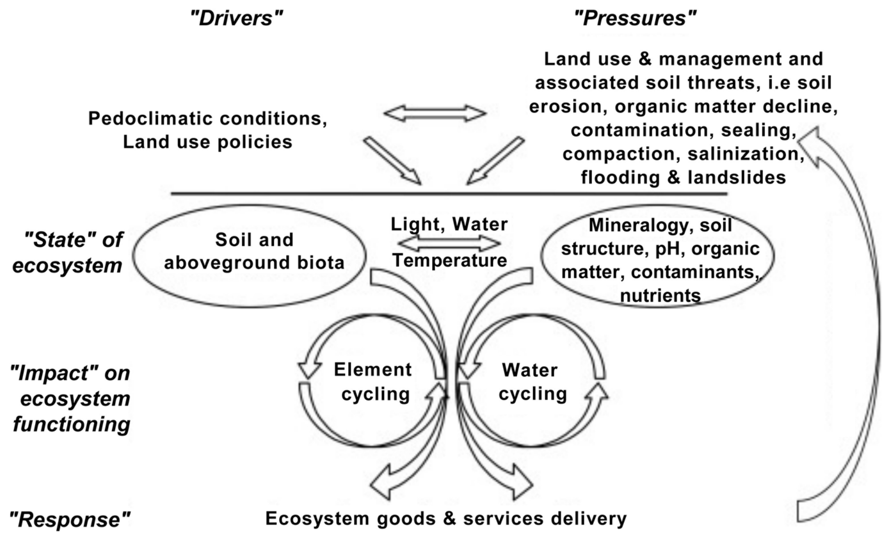

Figure 5. The Driver-Pressure-State-Impact-Response framework applied to soil (Bünemann et al. 2018)

(Change), Welfare, Response) proposed by Villamagna et al. (2013) aims at using ES semantics. By evaluating an ES as the difference between two ecosystem states under different pressure levels, this approach is of particular interest when providing a framework dedicated to the analysis of the multifunctionality of soil dynamics (Banwart et al. 2012; Xue et al. 2015) over climate or land-use changes. Other frameworks, dedicated to soil functions rather than to the soil ES (Vogel et al. 2018, 2019), for example, will also be considered, especially for the evaluation of the soil quality.

Smeets and Weterings (1999) suggested a "Typology of indicators" and the DPSIR framework used by the European Environment Agency in its reporting activities.

In relation to policy-making, environmental indicators are used for three major purposes: (1) to supply information on environmental problems in order to enable policy-makers to value their seriousness; (2) to support policy development and priority setting by identifying key factors that put pressure on the environment; (3) to monitor the effects of policy responses.

In addition, environmental indicators may be used as a powerful tool to raise public awareness on environmental issues (Smeets & Weterings 1999).

Environmental indicators generally reflect a systems analysis view of the relationships between the environmental system and the human system (Figure 6) (Smeets & Weterings 1999).

The DPSIR framework is useful in describing the relationships between the origins and consequences of environmental problems, but, in order to understand their dynamics, it is also useful to focus on the links between the DPSIR elements (Smeets & Weterings 1999).

The Ecosystem Approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.

The Ecosystem Capacity was defined as the ability of an ecosystem to generate a service under current ecosystem condition and uses, at the highest yield or use level that does not negatively affect the future supply of the same or other ecosystem services from that ecosystem (Hein et al. 2016).

The ES Potential supply is the ecosystems' ability to generate services irrespective of the demand for such services (Weber 2007; Villamagna et al. 2013; Hein et al. 2016).

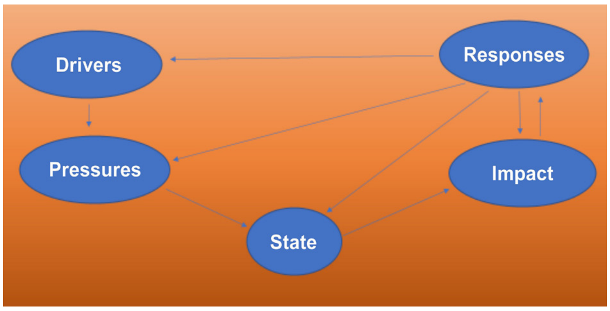

Figure 6. Classification of environmental indicators; the DPSIR framework for reporting on environmental issues

The ES Capability is an ecosystem's ability to sustainably generate one ecosystem service under the current condition and type of use and irrespective of the potential impacts of the increasing supply on the supply of other ecosystem services (Hein et al. 2016).

The ES Flow is a function of the (agro)ecosystem type (e.g., arable or horticultural land, dairy grassland), its biophysical setting and condition and its accessibility and use by people (adapted from Hein et al. (2016)).

Based on MEA, degradation is interpreted as a change in an ecosystem condition negatively affecting the ecosystem's structure, functioning, resilience and/or ability to provide ecosystem services. Depletion is more commonly interpreted as a reduction in a specific, harvested stock, as in depleting fish or timber stocks. Degradation may involve the depletion of stocks contained in the ecosystem, but may also be confined to changes in processes or resilience. Both degradation and depletion reflect changes in the ecosystem asset.

Flows to people have been labelled 'final ecosystem services' whereas flows of services between ecosystems are often referred to as 'intermediate services' or 'intra-ecosystem flows'.

Soil processes and 'soil functioning' have also be called supporting services and are now considered as intermediary services (Haines-Young & Potschin-Young 2018).

The Reference, or Reference Value is a value for an indicator representing the normal background value for defined local circumstances (ecological conditions), usually defined within the spatial boundaries of a Member State, but referring, in general, to the soil type, climatic zone and elevation, and sometimes land use, crop type and management. The term is equivalent to "normal operating range" (Kowalchuk et al. 2003) as used for biological indicators.

Sustainable soil management (SSM)

"Soil management is sustainable if the supporting, provisioning, regulating and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity. The balance between the supporting and provisioning services for plant production and the regulating services the soil provides for water quality and availability and for atmospheric greenhouse gas composition is a particular concern" (FAO 2017a).

Sustainable development goals

The debate over sustainable development goals (SDG) has great significance. These goals have been set until 2030 (Ronchi et al. 2019) in order to counter global challenges including concerns about the natural environmental and human well-being. The goals are mutually connected and achieving them requires devoting attention to the planet's ecosystems and resources – the soil, water and air (Veidemane 2019).

Assessment and evaluation of soil quality

There are many frameworks with which to assess and evaluate the soil quality. Although these frameworks share the aim of providing a purposeful description of the soil quality, they can be divided into two groups with regard to their main focuses.

The first group is comprised of a framework of indicators that describe the current state of the soil system assessment for evaluating the quality of agricultural land. This is based on detailed measurements of the terrain (Arshad & Martin 2002), a statistical analysis of soil databases or processing the status of specific threats to the soil. Analysing statistical soil databases is used to ascertain which soil characteristics and functions are the most important for a high-quality soil (Shukla et al. 2006; Desaules et al. 2010).

The second group is a framework of indicators focused on changes in the soil quality and applied soil management. This framework deals with the productivity of a soil in various systems of farming (Oberholzer et al. 2012), compare agricultural systems (Fliessbach et al. 2007) or discuss, in detail, the advantages of soil biota as indicators of the soil quality (Schloter et al. 2003; Bastida et al. 2008). Many of the designs of the soil quality indicators focus on soil management in the context of a single discipline such as agriculture or water pollution.

Soil quality frameworks designed for regional planning are rare. According to Drobnik et al. (2018), in Germany, they developed a concept for considering the soil quality in regional planning in the Stuttgart region. Another similar concept has been developed in Austria. Both of these concepts focus exclusively on limiting any settlement expansion and the related infrastructure. The German concept divides soil quality using scores (the higher the score, the better the soil) based on natural soil functions and anthropogenic soil degradation (landfills). The natural soil functions are the suitability for agriculture and plants, water retention and a filter for polluting materials. The author then assigns the availability of soil quality points to municipalities for new urban areas.

Haslmayr et al. (2016) also consider different soil functions to determine the overall soil quality, which is then implemented as a so-called spatial resistance for developing a place. The functions assessed include the habitat for organisms, the habitat potential for natural plant communities, natural soil fertility, and others. The spatial resistance of a soil depends on the highest performance of the soil function being assessed (the higher the performance, the higher the resistance). If a soil achieves the highest spatial resistance score, it is considered to be an area where any anthropogenic development requires compensatory measures. Many authors agree that several indicators of soil quality are needed if the soil quality is to be implemented in decision-making processes in a meaningful way (Drobnik et al. 2018).

SQUID index

The SQUID index uses the results of the Delphi survey to identify the contribution of the soil functions to the ES. For each service, the SFAs contributing to the service were multiplied by the weight factors provided by the experts. The resulting ES values were then averaged to the SQUID index. Equation (1) gives the details: ES_i are soil-based ES, with i running from 1 to 23. sf_{ij} is the quality of the soil function j contributing to a given ecosystem service i. w_{ij} is the expert-assigned weight, i.e., the contribution level of the soil function j to an ecosystem service i. The minimum overall score is 0 (the soil does not contribute to an ecosystem service at all), the maximum score is 5 (the soil contribution to an ecosystem service is very high).

The SQUID index is calculated according to the following equation:

$$\mathrm{SQUID} = \frac{\sum_{i=1}^{n} \mathrm{ES}_i}{i} \tag{1}$$

Auxiliary calculations (Drobnik et al. 2018) are:

$$\mathrm{ES}_i = \sum_{j=1}^{n} sf_{ij} \times w_{ij}$$

$$\sum_{j=1}^{n} w_j = 1$$

where:

ES_i – soil-based ecosystem services with i taking values from 1 to 23;

sf_{ij} – the quality of the soil function where j contributes to a given ecosystem service denoted by i;

w_{ij} – the weight assigned by experts, i.e., the level of contribution of soil function j to ecosystem service i.

BOKS index

The BOKS index was developed for application in the greater Stuttgart region in Southern Germany (Wolff 2006). It is based on a total of six attributes, which are used to characterise the soil quality. Unlike many other soil quality indices, BOKS considers both natural as well as anthropogenic factors that make up the final soil quality index. Four of the six attributes belong to natural factors – suitability for natural vegetation and cultivated crops, regulation of the water cycle, capacity for filtering and buffering contaminants and archiving cultural and natural history. The remaining two anthropogenic attributes include contaminated sites and the soil sealing level. Each attribute is normalised from 0 (does not exist) to 5 (very good). The original BOKS is parcel based, i.e., each attribute value originates from a point within the respective parcel, which is then multiplied by the area of the parcel it belongs to. To achieve the final BOKS score, the area scores for all the attributes are summed up following Wolff (2006) (see Equation (2)).

$$\begin{aligned}\mathrm{BOKS} = {} & (svc \times a) + (wc \times a) + (fbc \times a) + \\ & + (cnh \times a) + (cont \times a) + (seal \times a)\end{aligned} \tag{2}$$

where:

a – parcel area;

svc – suitability for natural vegetation and cultivated crops;

wc – regulation of the water cycle;

fbc – filtering and buffering capacity;

cnh – archiving cultural and natural history;

$cont$ – contaminated sites;

$seal$ – soil sealing level.

Drobnik et al. (2018) used a high-resolution map and, thus, calculated BOKS on the level of individual rasters (raster maps). Thanks to the high resolution, BOKS could be calculated on the level of single cells and multiplication with the parcel area was not necessary.

Comparing soil quality indexes

Effective and informed decision-making in terms of land development requires the constant assessment of land use and its impact on the environment. This is even more necessary today, when conflicts over land resources are increasing (O'Neill & Walsh 2000; von der Dunk et al. 2011; Hersperger et al. 2015). In order to avoid hidden compromises in terms of soil quality, and to incorporate the soil quality more effectively into land-use planning, information is needed not only on the absolute value of the soil quality, but also on its spatial distribution (Drobnik et al. 2018).

Environmental assessment methods in the EU

In Europe, the evaluation is mainly carried out using a multi-criteria analysis (MCA).

An MCA is a method that is used when deciding between several alternatives, not allowing for multiple resulting alternatives at the same time, and the conclusion of the analysis should always be a single alternative. A prerequisite for using a multi-criteria analysis is a larger number of quantifiable criteria to include in the decision-making process.

Multi-criteria decision making arises wherever the decision maker evaluates the consequences of his/her choice according to several criteria, when we introduce an appropriate scale (Sezima et al. 2018).

Multi-criteria decision making is always an analytical hierarchical process (Ramík 1999). An important step in the evaluation of multi-criteria problems is the determination of weights (importance of criteria). A wider range of methods can be used to determine them. One possible alternative is the scoring method. This method is one of the least computationally demanding, but, at the same time, the quality of the results obtained through it is lower. The more important the criterion, the higher the score. This method is burdened by a large degree of subjectivity in the respondent's assessment. (Fiala 2008).

Another possibility is using the Saaty method (Saaty 2008).

The benefit is that it allows the criteria to be compared regardless of the units used to express their value. It is popular in modern decision-making processes due to the fact that intangible, objectively unmeasurable variables can also be evaluated.

Saaty's analytic hierarchy process (AHP) method was also the basis for Šauer (2007), who described the use of a multi-criteria analysis for assessing the environmental quality. The aim in this case was to aggregate the qualities of individual environmental factors into a single number - an index - that would represent the quality of all of them together.

CONCLUSION

Soil protection within the EU has become a key issue in recent decades and will remain a key issue in the future. The European Green Deal (EGD) includes, among other things, measures for sustainable land management. The European Green Deal aims to operationalise the adoption of the Voluntary Guidelines for Sustainable Land Management (FAO 2017b).

In May 2020, the European Commission adopted the new EU Biodiversity Strategy 2030 and Action Plan for a long-term and comprehensive strategy to protect nature, including soils, and halt ecosystem degradation. The objectives of the soil strategy include legally protecting at least 30% of EU soils, reducing the urban sprawl, reducing risks from pesticide use, designating 10% of agricultural land as landscape features, managing 25% of the EU agricultural land in an environmentally sound way, making progress in remediating contaminated sites and reducing land degradation. Ronchi et al. (2019) state that although the value of soil is increasingly recognised, there is no valid EU agreement on common and effective approaches to address soil threats in a systemic way and to use ecosystem services more sustainably. In order to reverse the negative trend in soil degradation, a comprehensive soil restoration programme needs to be implemented as recommended by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem (IPBES) (2019). This should include a commitment from the European Union:

"Protect soil functions, in particular soil fertility, and achieve soil degradation neutrality in the EU, address specific drivers that reduce soil biodiversity, carbon storage and fertility and apply sustainable soil management practices; Increase efforts to reduce soil erosion and increase soil organic matter and increase the integration of land use considerations into decision-making at all levels of governance, supported by the adoption of achievable targets; Take into account the direct and indirect impact of EU policies on land use in the EU and globally, with the aim of achieving a cessation of land grabbing by 2050; Make significant progress in the identification and remediation of contaminated sites; Reduce soil contamination by toxic substances in agricultural land to minimal levels; Substantially reduce agricultural areas with high soil erosion rates by 2030" *(*IPBES 2019).

"Soil conservation is significantly related to the soil valuation. It is the concept of ecosystem services that allows for a comprehensive valuation of the soil itself, but also of the benefits it provides."

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