European briefings

Soil

The ability of soil to deliver ecosystem services — in terms of food production, as biodiversity pools and as a regulator of gasses, water and nutrients — is under increasing pressure. Observed rates of soil sealing, erosion, contamination and decline in organic matter all reduce soil capability. Organic carbon stocks in agricultural soil may have been overestimated by 25%.

A coherent soil policy at EU level would provide the framework to coordinate efforts to survey soil status adequately.

Context

The degree to which society can benefit from soils is dependent on how it uses and manages them. Soils that are sealed for urban development or transport infrastructure lose most of their functions due to disrupted water, nutrient, and biological cycles. This loss is close to irreversible.[1]

Equally, soils can be degraded by the interplay of human and natural processes that cause decline in organic matter and biodiversity, compaction, and erosion by wind and water. Mineral or groundwater extraction can lead to pollution and affect soil stability, even causing subsidence in some urban areas; while large-scale drilling for shale gas production may add to existing contamination processes.

These phenomena affect the delivery of soil-based ecosystem services and can be costly or difficult to resolve. In recognition of these pressures and the importance of soil functions, the European Commission launched a Thematic Strategy on soil, which called for the protection and sustainable use of soil[2] while highlighting several vital soil functions: providing biomass and raw materials; storing, filtering and transforming substances; and acting as a carbon and biodiversity pool, as a platform for human activities and the landscape, and as an archive of heritage.

Soils received further recognition when the UN Rio+20 Summit[3]highlighted soil degradation as part of land degradation, and called for a land-degradation-neutral world in the context of sustainable development, a goal to which the EU subscribed. This target is reiterated in the European Union's 7th Environment Action Programme (7th EAP).[4]

Converting broad policy positions into action requires increased efforts and related targets to reduce soil erosion, to increase soil organic matter and preserve soil biodiversity, to remediate contaminated sites, and to limit soil sealing.

Key trends

Quantifying soil-based ecosystem services, in terms of the physical services provided and their economic value, is a relatively recent research area. While it is currently not possible to describe trends in soil functions, some baseline data are available at pan-European level.[5] More detailed data may exist at national levels.

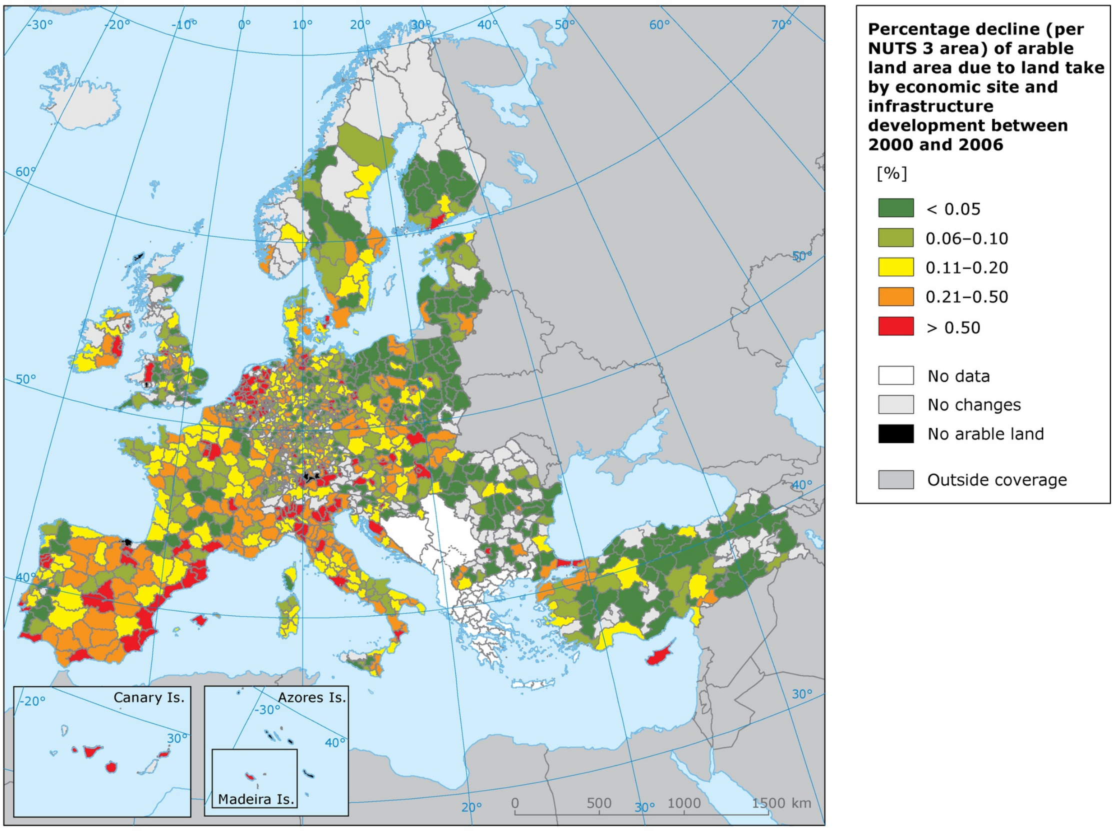
Biomass production as a provisioning service of soil

Soils are used to produce a range of biomass products that serve as food, feed, fibre and fuel. Biomass production can be particularly relevant in biodiversity conservation and climate change mitigation efforts, through supporting elements of 'green infrastructure'[6][7] and flood regulation.

An EU-27 baseline study of biomass production under arable land, grassland[8] and woodland[9] showed that on arable land, local soil quality determines to a greater extent the variability of the biomass production potential than climate. Thus, in most regions, well-managed arable land that preserves the soil quality can compensate for climatic handicaps. However, in the Mediterranean area, good management may not be sufficient to make up for climatic limitations.

Three other factors that affect biomass production are soil management (including irrigation and fertilisation), soil degradation processes (e.g. soil erosion) and 'land take'.[10] From 2000 to 2006, 0.26% of the production potential on arable land in the EU-27 was lost as a consequence of land take;[11][12] over the period 1990–2006, this loss amounted to 0.81%.[13] Map 1 illustrates the issue in relation to industrial and commercial sites plus transport networks and indicates some hotspots.

Map 1: Percentage decline (per NUTS 3 area) of arable land area due to land take by economic site and infrastructure development between 2000 and 2006



Sources: ETC SIA based on Corine Land Cover 2000 and 2006 .
Note: Orange and red areas are interpreted as hotspots.

Soil organic carbon pool as a regulating service of soil

A key service provided by soil is the storage and release of organic matter and carbon. Soil organic matter is essential for biomass production and for sustaining biodiversity. Soils can offset other greenhouse gas emissions by capturing and storing carbon, and they can help to adapt to climate change (e.g. in flood regulation owing to the structuring effect of soil organic matter).

Soil organic carbon (SOC) stocks in the EU-27 have been estimated at 75–79 billion tonnes.[14][15] Modelling results from the CAPRESE project suggest that prior assessments may have overestimated the SOC pool in agricultural topsoils[16] by around a quarter.[17][18] This highlights the need for systematic monitoring and the even greater importance of soil organic matter conservation.

The removal of topsoil by erosion is a worrying phenomenon as it impacts on SOC stocks and causes various off-site issues (e.g. siltation[19] of water bodies).[20] A recent study estimated that 130 million ha were affected by water erosion in the EU-27.[15] Improvements in modelling[21][22] are leading to higher precision in erosion estimates.[23][24]

Storage, filtration and transformation as a supporting service of soil

Soil stores, filters and transforms a range of substances including nutrients, contaminants, and water. In this context, soils act as a biological engine, controlling many key natural life cycles. In parallel, this function in itself implies potential trade-offs: a high capacity to store contaminants may prevent groundwater contamination, but this retention of contaminants may be harmful for biota.

The issue of contamination is crucial for this function as both diffuse and point source pollution[25] can impact human health and ecosystem services, thus affecting a soil's capacity to 'regenerate'. On the basis of non-harmonised national inventories, local soil contamination in the EEA-33 plus the 6 cooperating countries has recently been estimated at 2.5 million potentially contaminated sites.[26] About one third of an estimated total of 342 000 contaminated sites in the EEA-33 plus the 6 cooperating countries have already been identified and about 15% of these have been remediated. However, there are substantial differences in underlying definitions and interpretations in different countries.

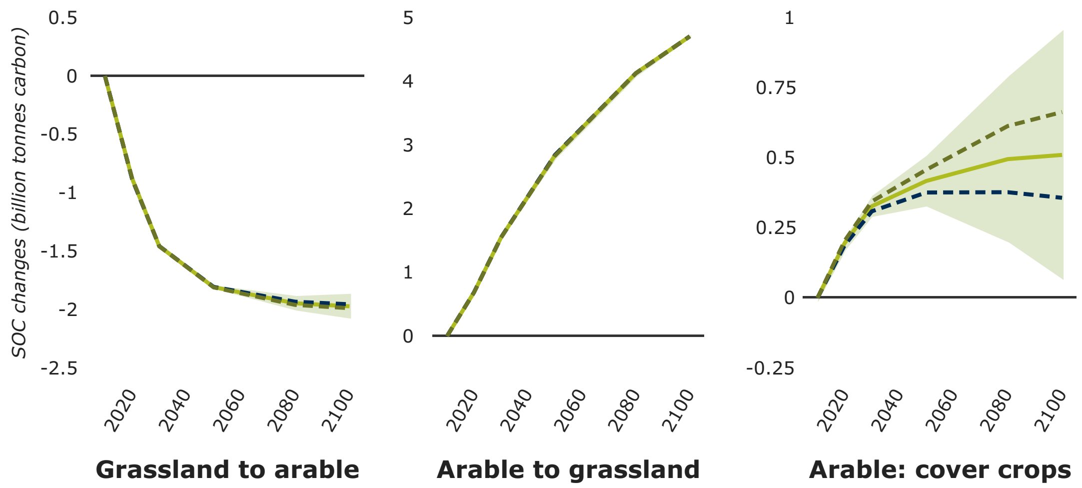
The intensity of soil use can considerably influence soil organisms, which in turn drive nutrient cycling.[27] High-intensity arable land results in lower diversity and biomass of soil organisms compared to land that is less-intensively cultivated or under permanent grassland.[28]

Prospects

As local soil quality largely determines biomass production potential on arable land, nutrient status plays a defining role. Soil fertility is the result of inherent soil characteristics (such as texture), nutrient inputs, and other management practices, which may strongly influence nutrient cycling. Europe-wide harmonised measurements of particular soil characteristics from the LUCAS Topsoil[29][22] and GEMAS[30] projects provide a picture of both the inherent characteristics of the soil and a signature of past soil use and management. Time series of soil characteristics, as expected from the continuation of the LUCAS Topsoil Survey, are required to assess changes and trends in biomass productivity.

The CAPRESE study found that the conversion of arable land to grassland is the most rapid method to gain SOC (Figure 1). Under future scenarios of arable land management, the use of cover crops[31] was found to be the most effective way of increasing SOC, although the effects are markedly regional due to climate. Such findings could be useful for estimating carbon emissions and removals from agricultural land in the context of LULUCF.[32] These results reinforce the message that land management is crucial in protecting, maintaining and improving the delivery of soil-based ecosystem services. This becomes even more relevant when considering that 40% of the EU area is agricultural land, managed in line with Common Agricultural Policy provisions that require land to be maintained in good agricultural and environmental condition. However, in the event of poor policy implementation, continued soil function loss is expected.

Figure 1: Soil organic carbon (SOC) change at pan-European level under different land use change and soil management scenarios [31]



Note: Values are projected to 2100 using two climatic scenarios. The blue and dark green interrupted lines correspond to the HADCM3_A1FI (HAD) ('world markets-fossil fuel intensive') and PCM_B1 (PCM) ('global sustainability') scenarios respectively; the former is more extreme, the latter more conservative. The bright green line is the average, while the light green region delimits the 2 σ confidence interval/variability. Scenarios were calculated using the CENTURY agroecosystem model.

Explore chart interactively

European Environment Agency

Source: CAPRESE project [17][18].

The lack of good-quality and harmonised soil data at pan-European scale, and the relatively undeveloped state of research on linking soil data with soil functions, makes it difficult to assess the prospects for soil functionality and soil-based ecosystem services. Only when robust baselines and a harmonised soil monitoring framework (addressing relevant soil functions and degradation processes) are in place can regular updates on trends be expected. Despite some promising projects, activities are clearly insufficient to deliver a comprehensive information and knowledge base to adequately support policy making in this area. Further research is thus needed to manage soils sustainably in the future. A binding and coherent soil policy at EU level would provide the framework to do so.

SOER 2015 European briefings present the state, recent trends and prospects in 25 key environmental themes. They are part of the EEA's report SOER 2015, addressing the state of, trends in and prospects for the environment in Europe. The EEA's task is to provide timely, targeted, relevant and reliable information on Europe's environment.

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