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POLICY, PERFORMANCE, AND GAPS: WASTE MANAGEMENT UNDER BULGARIA'S OPERATIONAL PROGRAMME "ENVIRONMENT"

GROZDANOVA-DZHOYKEVA, GERGANA[1]

Abstract
Environmental protection is a top issue for all countries. In Bulgaria, a number of programs, projects, and initiatives are being conducted to reduce the environmental effect of human activities. Waste regulations in the European Union serve as both environmental tools and strategic levers for attaining climate neutrality, resource efficiency, and green economic transformation. In this respect, Bulgaria's Operational Programme "Environment" (OPE) is an important national tool for harmonizing waste policy with EU environmental regulations. Given the increased social and legislative emphasis on decreasing environmental harm through better waste governance, this article presents a current and relevant assessment of how OPE has helped Bulgaria advance in the waste management sector. It closes a significant vacuum in the literature by providing a thorough, data-driven analysis of the program's effects, problems, and limits, as well as proposing priority areas for policy and operational development over the 2021–2027 programming term. This article examines the Operational Programme "Environment" (OPE)'s ability to enhance environmental protection, with a particular emphasis on waste management programs.To attain this goal, the following research tasks are completed: A literature analysis of current advancements in the waste management component of the OPE; An examination of the types and structures of waste produced in Bulgaria; An assessment of waste-related projects funded by the OPE. The analysis is based on official statistics data and uses both qualitative and quantitative research methodologies. The findings will be used to propose ideas for increasing the program's efficacy, as well as to highlight critical weaknesses in its present performance.

Keywords: environment, waste management, operational programme
JEL: Q53, Q58, Q01

Introduction

The European Union places a high focus on environmental conservation. Climate neutrality by 2050 is outlined in the European Green Deal (European Parliament, 2024). The EU's circular economy policy places a strong emphasis on waste laws (European Commission, 2025). The primary instrument for bringing Bulgaria's national waste strategy into compliance with EU regulations is the Operational Programme "Environment" (OPE) (Interreg Europe, 2020). Nevertheless advancements, Bulgaria is still experiencing a high landfilling rate and poor recycling rates (EEA, 2024). The effect of OPE on waste management is evaluated in this paper. It

[1] PhD Student, Department of Natural Resources Economics, University of National and World Economy, Sofia, Bulgaria, e-mail: gergana.grozdanova@unwe.bg

examines results, points out shortcomings, and suggests goals for the programming period 2021–2027.

Literature review of the waste management

One of Bulgaria's ongoing environmental problems is waste management. The nation produces between 2.7 and 3.0 million tons of municipal garbage per year, or around 500 kg per person, which is comparable to the EU average (Eurostat, 2023; Ministry of Environment and Water, 2021). Slower progress towards the goals of the circular economy is seen in the content and management of this trash, which nevertheless deviates greatly from European trends (European Commission, 2021).
Waste structure. Biodegradable fractions like food and green garbage make up the biggest portion of municipal trash, with plastics, paper, metals, and glass coming in second and third, respectively (Marinov et al., 2024; EEA, 2024). A sizable amount of the total is made up of industrial waste streams, such as materials used in building and demolition, whereas hazardous waste, despite its small volume, poses serious problems because of insufficient treatment and monitoring capabilities (Koleva, 2019; EEA, 2022).
Methods of management. The system is still dominated by landfilling; in 2022, between 54 and 55 percent of municipal garbage was landfilled, compared to the EU average of just 23 percent (Eurostat, 2023; OECD, 2021). Due to Bulgaria's inadequate waste-to-energy infrastructure, recycling and composting combined account for around 25% of total energy recovery (Petrova & Dimitrov, 2020; European Parliament, 2020). There are distinct collecting systems, but they are not all developed equally; in major metropolitan towns, they are more efficient, while in rural regions, they perform poorly (Stoyanov, 2018; Ivanova, 2021).
Success and difficulties. With the help of the Operational Programme “Environment”, Bulgaria has achieved significant strides in the last ten years in developing regional waste management systems and shutting non-compliant landfills (Ministry of Environment and Water, 2014; European Commission, 2019). However, structural impediments such as insufficient enforcement mechanisms, low public engagement in separate collection, and differences in local administrative competence are still recognized (Bashev, 2008; Yarkov, Stankov, & Stankov, 2022). It will be necessary to rapidly expand recycling infrastructure in addition to strengthening financial incentives, public engagement strategies, and governance in order to meet the EU's ambitious targets of 55% recycling by 2025 and lowering landfilling to less than 10% by 2035 (EEA, 2024; European Commission, 2021).
Techniques

Metodology and data

The research evaluates waste management under Bulgaria's Operational Program "Environment" (OPE) using a mixed-methods methodology. Based on official data from Eurostat and the Ministry of Environment and Water, it analyzes the types and structure of waste created in Bulgaria and reviews the literature on OPE and EU waste policy. The third component uses reports from the European Commission and EEA to evaluate initiatives funded by OPE. Performance was tracked using quantitative metrics, such as recycling and landfilling rates, while structural and governance issues were found using qualitative content analysis. The methodology, which focuses on both program outputs and observable environmental impacts, spans the three OPE programming years (2007–2013; 2014–2020; and 2021–2027).

Analysis of policy, performance, and gaps: waste management under Bulgaria's operational programme "Environment"

A robust regulatory framework for waste management has been built by the European Union. The Landfill Directive 1999/31/EC concentrates on lowering landfilling and related dangers, whereas the Waste Framework Directive 2008/98/EC (modified by Directive 2018/851) establishes the waste hierarchy, enhances prevention, and expands producer responsibility (European Commission, 2018). Bulgaria and other Member States use these tools as a basis to match their national policies with the EU's circular economy goals (European Environment Agency, 2024). Despite its advancements, Bulgaria continues to trail below the EU average. Only 25% of the nation's municipal garbage was recycled in 2022, compared to 49% in the EU-27, and about 54% was landfilled (Eurostat, 2023). These ongoing difficulties highlight how crucial national tools like the Operational Programme "Environment" (OPE) are in assisting with governance and infrastructural improvements. An outline of OPE's history. Launched in 2007 as part of Bulgaria's EU admission, the Operational Program "Environment" has undergone three programming periods(table 1):

1. Aligning with EU directives, particularly in the areas of waste and wastewater management, was the primary focus from 2007 to 2013. Establishing recycling programs, shutting non-compliant landfills, and developing regional waste management systems were prioritized (Ministry of Environment and Water, 2014).
2. 2014–2020: The program's scope was extended to include six priority axes, with waste management emphasizing separate collection, integrated regional systems, and recycling capacity. funding reallocation to improve waste diversion from landfills was made possible by changes in financing (Ministry of Environment and Water, 2021).

3. 2021–2027: The current programm places a strong emphasis on meeting the new circular economy goals set by the EU. Investments in sorting facilities, enhanced separate collection, upgrading of municipal waste systems, and the restoration of former landfills are given top priority (European Commission, 2021). Bulgaria's requirement to conform to more ambitious EU goals, such as the European Green Deal and the Circular Economy Action Plan, is reflected in the current programming period. The OPE 2021–2027 waste component places a high priority on the rehabilitation of former landfills, the modernization of municipal trash services, and investments in sorting facilities. With the goal of increasing recycling rates to at least 55% by 2025 and reducing landfilling to less than 10% of municipal garbage by 2035, the emphasis has changed from compliance to performance. The inequitable administrative and financial ability of municipalities to execute EU-level requirements continues to be a significant obstacle, therefore the effectiveness of OPE's initiatives is essential to reaching these long-term goals.

Table 1. Periods of Waste management programme

Programming period	Main priorities in waste management	Key results/challenges
2007–2013	Alignment with EU directives; construction of regional waste management systems; closure of non-compliant landfills ; Integrated regional systems	Significant reduction of illegal landfills; slow start of recycling capacity
2014–2020	Promotion of separate collection; expansion of recycling and recovery capacity	Improved infrastructure; uneven implementation across municipalities
2021–2027	Compliance with EU circular economy targets; investment in sorting facilities; landfill rehabilitation; modernization of municipal waste services	Ongoing implementation; pressure to meet EU 2035 targets on recycling and landfill diversion

Source: MOEW

Although academics have highlighted that OPE is Bulgaria's most crucial financial tool for environmental compliance with EU regulations, they also point out that assessments frequently concentrate on outputs (the quantity of projects or facilities constructed) rather than long-term results (Bashev, 2008; Yarkov, Stankov, & Stankov, 2022). This leaves room for factual, data-driven research evaluating the program's actual environmental impact.

Figure 1 illustrates data from the European Commission (2021) and Eurostat (2023), which lead us to the conclusion that Bulgaria's municipal waste management continues to improve but still falls short of EU standards. As a result of regional waste systems and the closure of non-compliant landfills, the percentage of landfilled garbage dropped from around 80% in 2010 to about 65% in 2020. These levels are still far higher than the EU average, though. Recycling is on the rise, rising from around 15% in 2010 to 25% in 2020. This falls well short of the EU's 2025 recycling goal of 55%, though.

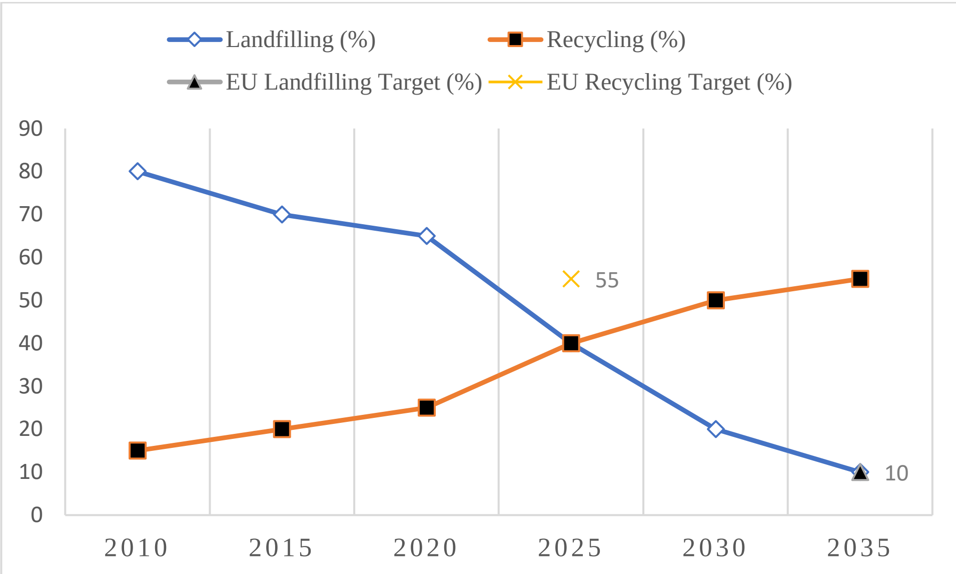

Figure 1. Progress of Bulgaria Towards EU Waste Management Goals: Recycling and Landfilling (2010–2035)

It will take a significant acceleration of actions, such as better separate collection, additional recovery facilities, and more stringent municipal compliance, to meet the goal of reducing landfilling to 10% by 2035. The number concludes by highlighting a structural issue: Bulgaria's recycling development is too sluggish, and the country is still too dependent on landfilling. Stronger enforcement of EU environmental regulations, the promotion of circular economy principles, and large investments in infrastructure upgrading will all be necessary to address this imbalance.

Findings and discussion

Even though Bulgaria's waste industry has received significant EU support under the Operational Programme "Environment" since 2007, a number of structural issues still restrict its efficacy.The nation's heavy reliance on landfilling is one of the most enduring problems. Compared to the EU average of just 23%, around 54–55% of Bulgaria's municipal waste was still disposed in landfills in 2022 (Eurostat, 2023). Landfilling continues to be the predominant practice, hindering efforts to achieve the goals of the circular economy, even after several non-compliant dumpsites have been closed and regional waste management systems have been established (European Commission, 2019; EEA, 2024). The unequal ability of municipalities to efficiently manage waste is another major problem. Due to a lack of administrative and financial resources, smaller rural towns lag behind larger cities like Sofia and Plovdiv in implementing more sophisticated systems for separate collection and recycling (Ministry of Environment and Water, 2021). This disparity leads to variable overall effect of OPE programs and regional performance differences. Separate collecting mechanisms have also been difficult to catch hold. Research indicates that public awareness initiatives have been restricted in reach and efficacy, and Bulgarian families are still not adequately motivated to sort their garbage (Stoyanov, 2018; Ivanova, 2021). Because of this, even with large investments in infrastructure and collecting containers, the percentage of recyclable items that are actually collected from domestic garbage is still low. Progress is further hampered by shortcomings in enforcement and monitoring. The European Commission has emphasized time and again that Bulgaria has difficulty guaranteeing uniform implementation of EU waste rules, with fines and penalties sometimes applied ineffectively at the local level (European Commission, 2019). The shift to more environmentally friendly waste management techniques is slowed down and incentives for compliance are undermined by this lax enforcement. Last but not least, OPE has come under fire for prioritizing infrastructure over circular economy initiatives. Regional systems, landfills, and sorting facilities were effectively funded by the program, but it hasn't done as much to promote reuse markets, the creation of secondary raw materials, or private sector innovation. Instead of promoting systemic change, analysts contend that this "infrastructure dependency" runs the danger of securing Bulgaria's place in conventional disposal models (OECD, 2021; EEA, 2024).

In conclusion, Bulgaria still faces systemic issues, including high landfilling rates, unequal municipal capacity, low public participation in waste separation, inconsistent enforcement, and limited integration of circular economy principles, even though OPE has helped the country comply with EU waste regulations and provided essential infrastructure. If Bulgaria intends to fulfill the EU's ambitious objectives of less than 10% landfilling by 2035 and 55% recycling by 2025, these problems must be resolved.

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SOIL HEALTH: DEFINITIONS, CRITERIAAND ECONOMIC DIMENSIONS IN THE EUROPEAN CONTEXT

PETROVA, SOFI-NIKOL MARIO[1]

Abstract
This report provides a comprehensive overview of the concept of “soil health,” examining its historical evolution, contemporary scientific definitions, key assessment criteria, and economic dimensions within the European Union. Through a structured literature review and analysis of major EU policy documents – including the EU Soil Strategy for 2030, the Farm to Fork Strategy, the Soil Monitoring Law, and the Soil Deal for Europe – the study traces how the understanding of soil health has shifted from a narrow focus on soil fertility toward a multidisciplinary concept that integrates biological, physical, chemical, ecological, and socio-economic perspectives.
Historically, soil health was assessed primarily through physical and chemical properties, with particular emphasis on soil fertility and humus content. By the 1930s, biological characteristics such as vegetation, organic matter, and microbial communities became central to the concept. Modern definitions by FAO and international researchers conceptualize soil as a “living system,” whose continued capacity to function determines its health. This includes the ability to sustain plant and animal productivity, maintain or improve water and air quality, regulate nutrient and hydrological cycles, and support biodiversity. European policy frameworks expand this understanding, highlighting soil as a key actor in climate regulation, carbon sequestration, food security, and the resilience of ecosystems and economies.
The report reviews the principal groups of soil health indicators – chemical, physical, and biological – and discusses the persistent challenges of establishing harmonized monitoring systems across the EU. European soils are highly diverse, spanning multiple climatic zones, soil types, and land-use practices, which complicates the definition of uniform threshold values. According to the European Environment Agency, coherent assessment requires integrated indicator sets, functional thresholds, and standardized sampling methods. The proposed Soil Monitoring Law aims to address these gaps by setting common criteria, harmonized methodologies, and mandatory monitoring across Member States.
From an economic perspective, the report emphasizes that soil health functions both as a private asset and a public good. Healthy soils generate direct economic benefits by improving crop yields, reducing input costs, increasing land value, and enhancing resilience to climate extremes. Indirectly, they provide essential ecosystem services – including carbon storage, water purification, flood mitigation, and biodiversity conservation – that are not reflected in traditional markets but carry substantial societal value. Conversely, soil degradation imposes significant economic losses, estimated at tens of billions of euros annually in the EU, through reduced productivity, environmental remediation costs, and increased vulnerability to climate risks.
The report concludes that maintaining soil health requires integrated scientific knowledge, effective policy implementation, and broad societal engagement. Expanding harmonized monitoring, strengthening advisory services and knowledge transfer, and increasing public awareness are

[1] PhD student, Business Faculty, Department of Economics of Natural Resources, University of National and World Economy, Sofia, Bulgaria, *email: sofipetrova@unwe.bg*

essential steps toward achieving the EU’s soil health goals for 2030 and ensuring long-term ecological and economic sustainability.

Key words: soil health, soil health indicators
JEL: Q10

Introduction

The current era is characterized by massive global phenomena such as food insecurity and malnutrition, poverty, climate change, biodiversity loss, land degradation, pollution, the modification of water and nutrients cycles, and widespread disease outbreaks. (FAO, 2022). The key to solving these challenges lies in recognizing the importance of natural resources and using them responsibly. Taking care of them means not just protecting the environment, but protecting our own health, economic stability, and future. Land and soil continue to be subject to severe degradation processes such as erosion, compaction, organic matter decline, pollution, loss of biodiversity, salinisation and sealing. This damage is the result of unsustainable land use and management, overexploitation and emissions of pollutants. (EC, 2021). Against the backdrop of interconnected global challenges, soil health gains crucial importance as a key factor shaping both ecological resilience and socio-economic development.

While global frameworks such as the “2030 Agenda for sustainable development” emphasize the necessity of protecting natural resources, the European Union has also placed soil at the center of its sustainability agenda. The “EU Soil Strategy for 2030” explicitly identifies healthy soils as a fundamental for climate neutrality, reversing biodiversity loss, a resilient food system and a circular economy. Complementing this, the proposed “Soil Monitoring and Resilience Directive’’ establishes a legal framework for assessing and restoring soil health across Member states. Moreover, initiatives such as the ‘EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil', and the EU Soil Mission “A soil deal for Europe” further highlight the European commitment to achieving land degradation neutrality, improving soil monitoring, and fostering innovation through living labs and lighthouses

Thus, in the European context, soil health is not only an ecological concept but also a socio-economic imperative, directly linked to agricultural productivity, climate action, and long-term sustainability.

Within this European context, the present study pursues three main objectives:

1. To examine the conceptual foundations of soil health, with a focus on existing definitions and their implications for research and policy.
2. To identify and analyze key criteria for assessing soil health, linking ecological indicators with socio-economic dimensions.

3. To evaluate the economic significance of soil health in the European Union, highlighting the interconnections between soil functions, agricultural productivity, ecosystem services, and long-term sustainability.

This report is based on a structured literature review and policy document analysis as: EU Soil Strategy for 2030, Soil monitoring and resilience directive, A Soil Deal for Europe, Directive of the European Parliament and of the Council on soil monitoring and resilience (Soil Monitoring Law), Soil monitoring in Europe: Indicators and thresholds, etc. The scope was limited to the European context, with global references included where necessary to trace the historical evolution of the concept. The selection of sources was guided by relevance to the European policy framework and soil health research. The review covered publications and policy documents issued between 2000 and 2024, including peer-reviewed scientific articles, EU strategies, directives, and reports from the European Commission and the European Environment Agency. Databases such as Scopus, ResearchGate, and official EU repositories were consulted, while global references were included only when essential for tracing the historical evolution of the concept.

Soil health definitions and conceptual frames

The concept of soil health has evolved for more than a century. Early references emphasized soil fertility through physical and chemical properties, particularly humus. By the 1930s, biological aspects were introduced, highlighting the role of vegetation, organic matter, and soil microbes. The USDA's 1936 report "Soil Health and National Wealth" expanded the idea by recognizing the contributions of plants, animals, and microorganisms. In the same period, links between soil and human health also began to appear. Between the 1940s and 1970s, research increasingly connected soil health with human well-being, the rise of organic agriculture, and the importance of soil organisms, laying the foundation for the modern multidimensional view of soil health. And by the 1970s soil health was defined as "the inherent replenishment of nutrients in the soil through the process of weathering and soil formation." (Brevik. Eric. 2019)

The global perspective:

„Soil health has been defined as the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal, and human health (Pankhurst. C. E. 1997). Thanks to this definition, in 2008, the FAO made the following statement: "Soil health is the capacity of soil to function as a living system, with ecosystem and land use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and weed pests, form beneficial

symbiotic associations with plant roots; recycle essential plant nutrients; improve soil structure with positive repercussions for soil water and nutrient holding capacity, and ultimately improve crop production" (FAO, 2008). This definition explicitly introduces a temporal component by emphasizing the continued capacity of soil to function, which highlights that soil health must be sustained over time rather than assessed at a single moment. It recognizes soil as a dynamic ecosystem whose biological processes are central to supporting life and environmental quality and expands the concept of soil health by explicitly linking it to biodiversity and ecological interactions. It highlights the role of soil organisms in regulating pests and diseases, forming symbiotic relationships with plants, and recycling nutrients, thereby framing soil health as a driver of ecosystem services. Additionally, the definition introduces the idea that healthy soils actively improve soil structure and enhance water and nutrient retention, emphasizing not only ecological sustainability but also direct contributions to agricultural productivity. In the context of the EU Soil Strategy for 2030, soil health can be understood as the capacity of soils to sustain their ecological, economic, and social functions, including the provision of food and clean water, the regulation of climate through carbon storage, the preservation of biodiversity, and the support of a circular and resilient economy.
In European documents such as the EU Soil Strategy for 2030, Farm to Fork Strategy, The Implementation Plan of the mission "A Soil Deal for Europe", we find precisely this conceptual framework: ’Soil health is defined as 'the continued capacity of soils to support ecosystem services’.

Table 1. How does the EU Soil Strategy 2030 present healthy soils?

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

Criteria for assessing soil health

As I noted at the beginning of this report, we have data showing that in 1910 the emphasis was on assessing soil fertility through physical and chemical properties, especially humus. In the 1930s, biological aspects were introduced, emphasizing the role of vegetation, organic matter, and soil microbes.
Now soil health can be evaluated either through composite soil quality indices or by employing individual soil health indicators. On the one hand, indices integrate physical, chemical, and biological attributes into a single aggregated measure,

thereby facilitating cross-soil comparisons. Nevertheless, they may generate inconsistent results and often provide limited guidance for practical management interventions (Stevens, 2015). On the other hand, indicators yield more detailed insights into specific soil properties; however, they are more difficult to quantify and compare across sites and regions.

Consequently, the development of robust and broadly applicable indicators and threshold values remains a significant challenge. In the European context this difficulty stems from the substantial heterogeneity of European soils, biota, and climatic conditions, as well as from the diverse political, economic, and social contexts that shape national priorities for target-setting and indicator selection. Within Europe, 23 major soil types have been distinguished, along with four dominant macroclimatic zones and eight officially recognized soil threats. Taken together, these factors create a complex matrix of vegetation growth conditions across the continent. (EEA, 2022).

Table 2. A simplified framework for soil health

Chemical Indicators	**Physical Indicators**	**Biological Indicators**
Soil pH	Soil texture	Microbial biomass
Soil electrical conductivity	Soil particle and bulk density	Population of soil micro and macro-organisms
Organic matter content	Penetration resistance of soil	Soil enzyme activities
Total carbon and nitrogen	Aggregate stability	Pollutant detoxification
Carbon exchange capacity	Soil water holding capacity	Soil respiration
Soil essential nutrient	Soil aeration and porosity	Soil pathogens
Heavy and toxic metals	Soil infiltration	

According to the EEA Report 08/2022 – Soil Monitoring in Europe: Indicators and Thresholds for Soil Health Assessments, the evaluation of soil health requires a coherent set of chemical, physical and biological indicators, complemented by functional thresholds. The most widely applied indicators include soil organic carbon (SOC), pH (acidity/alkalinity), nutrient balance, contaminant levels (e.g. heavy metals, organic pollutants), erosion rates, soil compaction, land cover and sealing, and biological diversity of soil organisms. These parameters are directly linked to the capacity of soils to sustain fertility, regulate water and nutrient cycles, and provide essential ecosystem services such as carbon storage and pollutant filtration.

Importantly, the EEA report 08/2022 stresses the role of thresholds, defined as critical values beyond which soil functions are impaired. For instance, SOC values below defined thresholds signal reduced fertility and diminished carbon sequestration potential, while excessive compaction or erosion indicates degradation of soil structure and resilience. Although the current knowledge base is substantial, harmonization challenges persist, particularly regarding the definition and monitoring of soil biodiversity indicators. To ensure comparability across Europe, the monitoring framework recommends the adoption of stratified sampling schemes and tiered indicator sets.

The "DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Soil Monitoring and Resilience (Soil Monitoring Law)" (EU 2023) sets out the main criteria for assessing soil health, their values and assessment methods. Attention is paid to biological, chemical and physical indicators that reflect the ability of the soil to maintain productivity, biodiversity and ecosystem services. Regular monitoring is required using harmonised methods and threshold values, which allows for comparability between different regions, while taking into account the specific national and local context.

Economic Dimensions of Soil Health

Healthy soils generate both direct and indirect economic benefits. Directly, they enhance agricultural productivity, reduce input costs, and increase land value, while also opening opportunities for carbon credit schemes. Indirectly, soil health contributes to climate change mitigation, reduces risks to public health, supports biodiversity, and prevents costly environmental degradation.

Healthy soils constitute a critical component of terrestrial ecosystem functionality and provide essential services that underpin both ecological sustainability and economic productivity in Europe. Cropland and grasslands in the EU provide EUR 76 billion worth of ecosystem services per year. (*European Commission, 2021*). They enhance agricultural resilience by maintaining soil structure, nutrient availability, and microbial activity, thereby increasing crop yield stability and improving nutritional quality. Also hosts the largest carbon pool in the terrestrial ecosystem, playing an essential role in the global carbon cycle and the regulation of climate change. (EEA, EC, 2024). They regulate hydrological processes by promoting water infiltration, retention, and filtration, which reduces the incidence of surface runoff, erosion, and flooding. Furthermore, healthy soils sustain high levels of biodiversity, supporting microbial, fungal, and invertebrate communities that contribute to nutrient cycling, plant health, and overall ecosystem resilience. The conservation and restoration of soil health thus directly contribute to the maintenance of ecosystem services, food security, climate regulation, and the socio-economic well-being of European populations, demonstrating the multidimensional value of soil stewardship.

Conversely, soil degradation imposes significant economic costs and threatens environmental and societal well-being. As the EU's largest terrestrial ecosystem, healthy soils sustain many sectors of the economy while soil degradation is costing the EU several tens of billion euros per year. It has been estimated that about 60 to 70% of soils in the EU are not in a healthy state (based on a definition of soil health applied in the context of the Mission ’A Soil Deal for Europe’, under the EU Horizon Europe research programme). Every year, about 1 billion tonnes of soil are washed away by erosion in Europe. Between 2012 and 2018 more than 400 km² of land was taken per year in the EU on a net basis.(EC, 2021). More broadly, soil degradation including nutrient depletion, contamination, and compaction – results in tens of billions of euros in losses each year, while undermining food security, reducing agricultural yields, and impairing ecosystem services. These costs extend beyond direct financial losses, encompassing increased expenditures for soil restoration, water treatment, climate adaptation measures, and mitigation of biodiversity loss. Moreover, degraded soils have indirect effects on human health by diminishing food quality and increasing exposure to pollutants, further amplifying economic and social burdens. The European Union’s policy frameworks, including the Soil Strategy for 2030 and the „Farm to Fork Strategy, recognize the economic and societal importance of soil health. These strategies emphasize the reduction of nutrient losses, sustainable soil management, and the promotion of practices that enhance soil biological activity, fertility, and resilience. By implementing preventive and restorative measures, the EU aims to safeguard soil-dependent ecosystem services, minimize economic losses from soil degradation, and achieve long-term sustainability across agricultural, environmental, and economic sectors.

The economic role of soil health in the European Union can be examined through the lens of cost–benefit analysis and the differentiation between market and non-market values.

This framework illustrates that soil health functions as both a private asset and a public good. From an economic perspective, the challenge is to increase the number of policies that internalize externalities and reward practices that ensure both private profitability and public sustainability. (Table 3).

Table 3

Market benefits	**Non-market benefits**	**Costs of degradation**	**Short-term vs. long-term trade-offs**
Healthy soils increase agricultural productivity by improving nutrient availability, water retention, and soil structure. These processes reduce the need for synthetic fertilizers, irrigation,	Soils provide climate regulation through carbon sequestration, water purification, flood mitigation, and biodiversity conservation. These services are not reflected in conventional markets	Degraded soils lead to declining yields, higher input requirements, and greater exposure to climate extremes. Beyond private farm losses, society bears the costs of water treatment, disaster	Intensive land use may provide immediate yield gains but accelerates degradation, resulting in long-term productivity decline and higher costs of restoration. By contrast, investment in

Market benefits	Non-market benefits	Costs of degradation	Short-term vs. long-term trade-offs
and pesticides, thereby lowering production costs	but can be valued through avoided damage costs or willingness-to-pay studies.	recovery, and public health impacts.	soil health through sustainable practices (e.g. cover cropping, reduced tillage, organic amendments) can appear costly in the short term but yields significant net benefits over time.

Conclusion

Healthy soils sustain essential functions such as nutrient cycling, water regulation, erosion control, and carbon sequestration, which collectively underpin farm productivity and resilience. From an economic perspective, these functions generate tangible benefits: higher and more stable yields, reduced dependency on external inputs, and lower risks associated with climate variability and extreme weather events. At the same time, soil provides nonmarket ecosystem services, such as carbon storage, biodiversity habitats, and flood mitigation etc. Degraded soils, by contrast, impose hidden costs, including yield losses, higher input requirements, reduced water retention, and long-term productivity decline. Such processes not only affect farm income but also generate externalities, leading to higher public expenditure on environmental remediation, disaster recovery, and climate adaptation.

This report highlights that soil health is both an ecological foundation and an economic asset, underpinning agricultural productivity, ecosystem services, and long-term sustainability. However, the current scale of degradation in the EU shows that policy commitments must be reinforced with more practical tools and wider societal engagement.

First, soil research and monitoring need to be expanded and harmonized across Member States, ensuring that robust data on soil biological, chemical, and physical indicators are regularly collected and made comparable. This is essential for the successful implementation of the Soil Monitoring Law. Also, knowledge transfer and information channels should be strengthened. Farmers, land managers, and local communities require accessible advisory services and demonstration projects (e.g., living labs, lighthouses) that translate scientific findings into practical soil management practices. Public awareness and education must be expanded, as soil health is not only a technical issue but a societal one. Campaigns that communicate the links between soil, food quality, water resources, and climate resilience can build broader support for sustainable soil policies.

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