Life Soil Ex-Post Study

Final Report




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Acronyms

AB	Associated beneficiary
EC	European Commission
EAFRD	European Agricultural Fund for Rural Development
EEA	European Environment Agency
ENV	Environment
EU	European Union
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
ISCO	In situ chemical oxidation
JRC	Joint Research Centre
KPI	Key performance indicators
LCA	Life cycle analysis
LTDory	LIFETrack Dory database
MS	Member State
NAT	Nature
RDP	Rural Development Programme
TMO	Technical monitor

Executive summary

The present study analyses 20 LIFE projects that had the objective of tackling at least one of the multiple issues affecting soils at European level. These projects ended between 2012 and 2019, therefore, it was possible to analyse the impacts after the LIFE funding. The study applied the standard methodology for ex-post monitoring missions of the LIFE programme, integrated with specific guidance focused on soil themes. The resulting assessment of the project impacts included environmental, policy and socio-economic aspects as well as implications for the relevant sectors, providing insights on projects' sustainability and innovation. The information was collected during ex-post monitoring missions (August to October 2022), and from interviews with stakeholders whenever was possible, providing a wider perspective on the actual results achieved during the projects' lifespan.

Due to the large variety of soil issues addressed, the projects involved in the study have been sorted into five main groups linked to the reference sector, that is, agriculture, remediation, land management, urban planning and monitoring. Since there is no European directive on soil, the projects targeted the soil issues identified by the EU soil thematic strategy (COM (2002) 179 and COM (2006) 231); significant connections with the objectives of the most recent EU soil strategy for 2030 (Communication COM/2021/699) also emerged during the study.

Various findings from the ex-post missions are worth highlighting in terms of project sustainability, impending threats, monitoring of impacts, stage of development of technologies, governance implications and dissemination of results. At least five agricultural projects developed **good practices** for soil protection/conservation, technologies and decision support tools for farmers who, to some extent, are still adopting them. Also, the methods developed by a couple of projects to reduce land uptake through an innovative planning approach are still in use by the relevant institutions. The high investment costs for implementing the proposed remediation technologies and lengthy bureaucratic procedures for obtaining permits from local authorities are two of the main **risks** for replication of the project outputs that emerged during the visits. Various types of monitoring have been put in place by the projects, but for the most part only those covering a small area have been properly continued in the after-LIFE period, as surveys on extensive areas are very expensive and require commitment for a long time to carry out the task. Only a few projects monitored the carbon fluxes over their project's duration, and not all stakeholders are aware of the climate change benefits generated by healthy soils. Also, some controversial results on the best way of managing peatlands to reduce GHG emissions were presented by a Latvian project. Thanks to the information collected, it was possible to rank the current stage of development of **technologies/methods** developed by the projects (according to six categories, from 'outdated' to 'established'). As for the **governance** aspects, some significant collaborations with regional authorities for the organisation of programmes and long-term actions have been developed by around one-third of the projects, especially those in the agricultural sector, through local plans for rural development, and also in the decontamination sector, through strategic programmes for the reclamation of polluted sites. The most common targets of the **dissemination** activities were research entities and public authorities, while more than half of the projects have kept their websites active. In particular, three are regularly updated, the online tools developed by the projects are still available, and the websites continue to register a good number of hits.

The impact of the projects on their respective sectors is generally limited, even in the case of successful continuation. Indeed, LIFE supports demonstration projects which usually can have only limited direct impacts at sectoral level but may often trigger positive developments. In this regard, three projects have been selected as case studies for the type and extent of replication achieved in their relevant sectors.

The final assessments and recommendations extracted from the analysis of the soil-related results generated in the after-LIFE period can be summarised as follows:

- **Sustainability** of project results in the agricultural sector is ensured by networks of various local stakeholders that play a key role in the value chain (e.g. farmers, agronomists, research entities and public bodies).
- Large-scale objectives, in terms of replication of project outputs, can be accomplished only when the soil-related interventions are enforced by regional or national regulations covering specific or multisectoral themes.
- After the projects end, the **environmental impacts** are rather mild due to the limited size of the projects and the lack of continuous support from local authorities or stakeholders.
- Some **policy** recommendations have been made by beneficiaries for the new EU Soil Health Law. These include: strong support for the enforcement of systems that ensure the conservation of healthy soils in land transactions; monitoring of soil management practices included in the common agricultural policy (CAP) payments through public funding; and mandatory targets at EU level for protection of soils.
- Aside from the concerns raised by a few beneficiaries, a European directive devoted to soil protection is considered essential to push Member States to enforce similar policies at national level.
- No projects generated additional revenues or jobs through project activities, but, in some cases, the success achieved acted as a driver for **economic benefits** at local level, especially in the agricultural sector.
- On the **communication** side, more efforts should be made to raise awareness of both technicians/professionals and citizens on soil issues. As a matter of fact, soil is a sort of 'invisible' element of the landscape which is often not adequately covered in the activities developed by projects dealing with other environmental aspects of the relevant territories.
- As a recommendation for the **LIFE programme**, it is desirable to have more projects devoted to soil themes and more projects located in central and northern Europe addressing specific soil issues.

Overall, the study confirmed that the thematic approach followed from LIFE14 onwards, entailing a more structured and result-oriented monitoring of project achievements, has laid the groundwork for a more streamlined assessment of project impacts and increased reliability of related data. However, further improvements could be achieved by focusing the next soil-related initiatives of the LIFE programme on more specific sectors and/or topics: this will ensure a more homogenous assessment of the results.

1 Introduction

This study comprises an analysis of the results of a **LIFE ex-post** on 20 concluded LIFE projects focused on **soils**. The assessment establishes the direct environmental and climate benefits of these projects, their policy impacts, relevance to the sector, sustainability and continuity. In addition, an effort was made to gather information on the economic benefits generated by the project outputs and to collect, when possible, reliable key performance indicators (KPIs).

The structure of the present ex-post study is based on the ENV ex-post exercise carried out in the previous contract on LIFE and the Urban Waste Water Treatment Directive (91/271/EEC). A similar structure was used in the 2020 ex-post on energy efficiency and the 2021 ex-post on marine nature. The new approach adopted for LIFE ex-post studies, which entails a methodology designed on a thematic basis, allowed three main objectives to be pursued:

1. To check the actual sustainability of the initiatives proposed by the projects to tackle soil issues over time.
2. To gather and evaluate possible contributions to the soil legislative proposal at European level and policy feedback on the actual implementation of relevant directives at least partially linked to soil.
3. To assess projects' direct impact on soil.

The selected LIFE projects fall into different sectors, such as land management, agriculture and urban planning, therefore multiple and varied environmental aspects linked to soil were taken into consideration. Overall, these projects were implemented in nine EU Member States and ended between 2012 and 2020, meaning it was possible to analyse the impacts after LIFE funding.

The main legislative reference underlying the specific objectives of the soil ex-post study was the *EU Soil Strategy for 2030 – Reaping the benefits of healthy soils for people, food, nature and climate*, published in November 2021. In this regard, the outcomes of this study can be considered as an input to the next European legislation on soil and to the design of voluntary actions from EU Member States for reaching the goals set by the above-mentioned strategy.

2 Policy background

The legislative initiatives on soil have been intensified recently at European level. In particular, in November 2021 the European Commission launched the **EU soil strategy for 2030** (Communication COM/2021/699), which sets out a framework and concrete measures to protect soils and ensure they are used sustainably. It sets a vision and objectives to achieve healthy soils by 2050, with concrete actions by 2030. It also announces a new **EU Soil Health Law**, to be presented in 2023 (currently under preparation) 'to ensure a level playing field and a high level of environmental and health protection'.

In line with the above goal, the following results are expected to be achieved by 2030:

- **Land degradation** including desertification in drylands is strongly reduced and 50% of degraded land is restored, moving beyond land degradation neutrality.
- High soil organic **carbon stocks** (e.g. in forests, grasslands, peatlands) are preserved and current carbon concentration losses on cultivated land (0.5% per year) are reversed to an increase of 0.1-0.4% per year. The area of peatlands losing carbon is reduced by 30-50%.
- No net **soil sealing** and an increased re-use of urban soils for urban development from the current rate of 13-50%, to help stop the loss of productive land to urban development and meet the EU target of no net land take by 2050.
- Reduced **soil pollution**, with at least 25% of EU farmland area under organic agriculture, a further 5-25% of land with reduced risk from eutrophication, pesticides, anti-microbials and other contaminants, and a doubling of the rate of restoration of polluted sites.
- Prevention of **erosion** on 30-50% of land with unsustainable erosion rates.
- **Improved soil structure** to improve habitat quality for soil biota and crops, including a 30-50% reduction in soils with high-density subsoils.
- 20-40% reduced global **footprint of EU's food and timber** imports on land degradation.

Moreover, soil-related targets are found in many of the strategies published as part of the European Green Deal, in particular:

- The farm to fork strategy (COM/2020/381 final)
- The 2030 biodiversity strategy (COM/2020/380 final)
- The zero pollution action plan (COM/2021/400 final)
- Climate adaptation strategy (COM/2021/82 final)
- The fit for 55 package (COM/2021/550 final).

It should be noted that in September 2021 the Commission launched five EU Missions, among which was 'A Soil Deal for Europe: 100 living labs and lighthouses to lead the transition towards healthy soils by 2030', within the framework of the Horizon programme.

This is the policy background taken into account for the soil ex-post study missions and the pertaining evaluations, in order to identify the most significant contributions and lessons learnt that LIFE projects can provide to achieve the above-mentioned objectives and to the design of the forthcoming EU Soil Health Law.

3 Purpose of the study

The main objective of this study was to examine the contribution of the LIFE programme in tackling the soil issues affecting the European territory, the potential replicability of the technical solutions proposed by the projects, and possible recommendations for the forthcoming European legislation for the conservation of healthy soils.

In quality terms, the data and feedback obtained during the ex-post monitoring enabled proper evaluation of the following aspects linked to the sustainability of the projects[1]:

- *Effectiveness:* the extent to which planned objectives have actually been reached/ realised by the projects.
- *Efficiency:* the extent to which costs associated with interventions are reasonable when compared to the quality, quantity and time of the project results.
- *Continuity:* the extent to which positive impacts have been continued or are likely to continue in the future.
- *Benefits:* the extent to which impacts address key environmental needs, priorities in specific EU policies and requests of the stakeholders concerned.

On a thematic basis, it was possible to assess the effectiveness of the systems and/or best practices proposed by the projects covering the following soil themes:

- Monitoring of soils' quality and health
- Remediation of polluted areas
- Soil conservation in the agricultural sector and on degraded land
- Increase of carbon sinks and carbon stocks in rural and natural areas
- Prevention of soil sealing and land uptake
- Conservation of ecosystem services provided by soils, such as organic matter, fertility and groundwater protection
- Prevention of loss of biodiversity in soils
- Awareness on soil issues among policy stakeholders, professionals and citizens.

1 According to the LIFE monitoring definition, project **sustainability** is the capacity to maintain a project's results after its implementation in the medium and long term, be it by continuation, by replication or by transfer.
Continuation means continued use by the entities involved in the project of the solutions implemented during the project after its end. Continuation may also entail further spread geographically.
Replication means that the solutions applied in the project are used again in the same way and for the same purposes by other entities/sectors during or after the project end.
Transfer means that the solutions applied in the project are used in a different way or for a different environment, climate action or related governance and information purpose by the same or other entities/sectors during or after the project end.

4 Methodology

The soil ex-post study is focused on concluded LIFE projects from nine Member States (Belgium, Denmark, Greece, Hungary, Italy, Latvia, Poland, Slovenia and Spain). The methodology was designed to carry out a proper assessment of the direct environmental and climate benefits of these projects, their policy impact, the relevance to the sector and their sustainability. In addition, monitors were particularly requested to collect, when possible, reliable KPIs, especially those related to the indicator '4.3 Resource efficiency – soil'.

For the selection of projects to be included in the ex-post analysis, the following sources were examined:

- LIFE Soil Platform Meeting (held in Athens in 2013)
- Pilot Study on Soil (2014) – *Contribution of LIFE projects to the implementation, dissemination and further development of EU environmental policies and legislation*
- LIFE public database
- LIFETrack Dory database (the NEEMO database).

In particular, the following criteria were used for the selection of projects:

- Projects specifically designed to address soil issues (e.g. erosion, contamination, soil sealing).
- Projects completed at least 2 years previously: for this reason, the most recent project falls in the LIFE 2015 call.
- Proved quantitative results achieved.
- Quality of the project according to the technical monitors' scoring.
- Maximisation of the geographical distribution across the EU.

As for the last point, it should be noted that the LIFE projects focused on soils are more frequent in southern Europe and that these projects are more diverse in terms of the environmental issues addressed. On the other hand, the projects based in northern Europe are more focused on contamination and degradation of soil quality.

As a result, **20 projects** focused on soil issues was selected and shared with CINEA and DG ENV. A reserve list of six more projects was prepared as well, in case one or more projects were not available for the ex-post visit (as happened in one case). The planning of all the foreseen missions was then defined in June 2022.

The 20 projects selected for this study are listed in Table 1 with an overview of the projects' duration and geographical distribution. Of these, 18 projects were funded under LIFE+ (2007-2013) and 2 under LIFE 2014-2020.

Table 1. Selected projects

PROJECT	ACRONYM	TITLE	STARTED	ENDED	CLOSED FOR (YEARS)	COUNTRY
LIFE07 ENV/ GR/000278	Soil Sustainability (So.S)	*Soil Sustainable Management in a Mediterranean River basin based on the European Soil Thematic Strategy*	2009	2012	10	GR
LIFE08 ENV/H/000292	MEDAPHON	*Monitoring Soil Biological Activity by using a novel tool: EDAPHOLOG-System*	2010	2012	10	HU
LIFE09 ENV/ DK/000368	NorthPestClean	*Demonstration of alkaline hydrolysis as a new technology for remediation of pesticide contaminated soil and groundwater*	2010	2014	8	DK
LIFE10 ENV/ BE/000699	DEMETER	*Sustainable and integrated soil management to reduce environmental effects*	2012	2016	6	BE
LIFE10 ENV/ ES/000511	EUTROMED	*Técnica demostrativa de prevención de la eutrofización provocada por nitrógeno agrícola en las aguas superficiales en clima mediterráneo*	2011	2015	7	ES
LIFE10 ENV/ IT/000400	New LIFE	*Environmental recovery of degraded soils and desertified by a new treatment technology for land reconstruction*	2011	2017	5	IT
LIFE10 ENV/ PL/000661	Biorewit	*New soil improvement products for reducing the pollution of soils and waters and revitalizing the soil system*	2012	2015	7	PL
LIFE10 NAT/ ES/000579	SOIL-Montana	*Agroecosystems health cards: conservation of soil and vegetal diversity in mountain and bottom valley grazing areas*	2011	2014	8	ES
LIFE10 ENV/ ES/000471	Crops for better soil	*Profitable organic farming techniques based on traditional crops: contrasting soil degradation in the Mediterranean*	2011	2016	6	ES
LIFE11 ENV/ ES/000505	BIOXISOIL	*New approach on soil remediation by combination of biological and chemical oxidation processes*	2012	2016	6	ES
LIFE11 ENV/ IT/000113	BIOREM	*Innovative System for the Biochemical Restoration and Monitoring of Degraded Soils*	2013	2015	7	IT
LIFE12 ENV/ ES/000647	LIFE+Farms for the future	*Farms for the future: Innovation for sustainable manure management from farm to soil*	2013	2018	4	ES
LIFE12 ENV/ ES/000761	DISCOVERED LIFE	*Lab to field, soil remediation demonstrative project: New ISCO application to DNAPL multicomponent environmental problem*	2014	2017	5	ES
LIFE12 ENV/ IT/000578	Help SOIL	*Helping enhanced soil functions and adaptation to climate change by sustainable conservation agriculture techniques*	2013	2017	5	IT
LIFE12 ENV/ IT/000719	CarbOnFarm	*Technologies to stabilize soil organic carbon and farm productivity, promote waste value and climate change mitigation*	2012	2018	4	IT
LIFE12 ENV/ SI/000969	LIFE ReSoil	*Demonstration of innovative soil washing technology for removal of toxic metals from highly contaminated garden soil*	2013	2018	4	SI
LIFE13 BIO/ IT/000282	SelPiBioLife	*Innovative silvicultural treatments to enhance soil biodiversity in artificial black pine stands*	2014	2019	3	IT
LIFE13 ENV/ IT/001218	LIFE SAM4CP	*Soil administration models for community profit*	2014	2018	4	IT
LIFE14 CCM/ LV/001103	LIFE REstore	*Sustainable and responsible management and re-use of degraded peatlands in Latvia*	2015	2019	3	LV
LIFE15 ENV/ IT/000225	SOS4LIFE	*Save Our Soil for LIFE*	2016	2020	2	IT

The **methodology** for the ex-post monitoring is based on the NEEMO document 'Methodology and Guidelines for LIFE Ex-Post Monitoring Missions' and on the related template for the visits. In addition, guidance specifically devoted to the ex-post exercise on soils, including specific thematic-related recommendations, was prepared and shared with the experts set to be involved in the 20 ex-post missions. The choice of experts was based not only on availability but also on thematic expertise, knowledge of the country context and evaluation skills relevant to the project.

The following table summarises the timetable of the soil ex-post activities implemented in 2022.

Table 2. Timetable

ACTIVITY	CONCLUSION (2022)
List of projects and concept note	Mid-March
Selection of experts for the ex-post missions	End of March
Guidelines for the missions	End of April
Planning of 20 ex-post visits	End of June
Visits to the selected projects	Mid-October
Final report	End of November

4.1 Ex-post missions

In order to harmonise the thematic information to be included in each ex-post mission report, specific guidance was developed to complement the standard ex-post guidelines. The aim of the document was to guide the technical monitors in the implementation of the thematic assessment at project level to obtain information related to the sectoral assessment, replication of project outputs and policy impacts. A specific training webinar was also organised with all the selected NEEMO TMOs, giving practical tips on how to conduct the ex-post analysis based on two previous and successful ex-posts (shared by Lynne Barratt and Ludovico Susani).

The assigned monitors prepared a programme for the missions, identifying the main places to visit (areas of project interventions) and people to meet (beneficiaries and stakeholders). These were conducted in the usual manner, that is, following the standard ex-post mission guidelines to ensure consistency with previous exercises. This was done by filling in an ex-post template adapted to the main soil themes to be covered during the visits.

The projects visited can be sorted into five categories – *agriculture, land management, urban planning, remediation and monitoring* – and cover common soil issues, such as erosion, loss of fertility and organic matter, local and diffuse contamination, biodiversity and soil sealing (see Table 3 below). Most projects fall in the agricultural sector (seven), five each in the land management and remediation sectors, two in urban planning and one in the monitoring field. Some soil issues are more directly linked to a specific sector: organic matter content to the agricultural sector, local contamination to remediation, and soil sealing to urban planning. On the other hand, the land management sector includes a wider range of soil issues as the related activities fall in different types of territories: water basins, peatlands, forests, etc.

Table 3. Soil sectors and issues

PROJECT	ACRONYM	SECTOR	SOIL ISSUES
LIFE10 ENV/BE/000699	DEMETER	Agriculture	Organic matter, fertility
LIFE10 ENV/ES/000471	Crops for better soil	Agriculture	Organic matter, compaction, fertility
LIFE10 ENV/ES/000511	EUTROMED	Agriculture	Diffuse contamination, erosion
LIFE10 ENV/PL/000661	Biorewit	Agriculture	Organic matter, diffuse contamination
LIFE12 ENV/ES/000647	LIFE+Farms for the future	Agriculture	Organic matter
LIFE12 ENV/IT/000578	Help SOIL	Agriculture	Organic matter, fertility
LIFE12 ENV/IT/000719	CarbOnFarm	Agriculture	Organic matter, fertility
LIFE07 ENV/GR/000278	Soil Sustainability (So.S)	Land management	Erosion, fertility, local contamination
LIFE10 NAT/ES/000579	SOIL-Montana	Land management	Monitoring, organic matter, fertility, biodiversity
LIFE11 ENV/IT/000113	BIOREM	Land management	Degradation, erosion, fertility
LIFE13 BIO/IT/000282	SelPiBioLife	Land management	Biodiversity
LIFE14 CCM/LV/001103	LIFE REstore	Land management	Peatland conservation
LIFE08 ENV/H/000292	MEDAPHON	Monitoring	Biodiversity
LIFE09 ENV/DK/000368	NorthPestClean	Remediation	Local contamination
LIFE10 ENV/IT/000400	New LIFE	Remediation	Compaction, degradation
LIFE11 ENV/ES/000505	BIOXISOIL	Remediation	Local contamination
LIFE12 ENV/ES/000761	DISCOVERED LIFE	Remediation	Local contamination
LIFE12 ENV/SI/000969	LIFE ReSoil	Remediation	Local contamination
LIFE13 ENV/IT/001218	LIFE SAM4CP	Urban planning	Sealing, land uptake
LIFE15 ENV/IT/000225	SOS4LIFE	Urban planning	Sealing, land uptake

The ex-post missions were carried out between the end of July and mid-October 2022, either with physical visits or online interviews, and mission reports were collected through the NEEMO Teams app ('Soil Ex-post 2022' team). These were checked by the coordinators of the study in terms of overall quality and coherence of the information obtained with the scope of the task.

The technical monitors were requested to assess the projects' thematic ex-post impacts in accordance with the monitoring methodology applied to the ongoing LIFE 2014-2020 projects. Lastly, the technical monitors prepared a draft letter for each project to give feedback to the beneficiaries; all the letters were checked and signed by CINEA.

The information provided in the mission reports has been used to draft the present report. When necessary, additional information was requested after the missions to enhance the reliability of the analyses carried out (i.e. quantification of the KPI values).

5 Ex-post mission results

The present section illustrates the results obtained from the projects during the ex-post visits. The section starts with an assessment of project sustainability as any other impact in the long term depends on this. In particular, the findings related to specific topics linked to soil themes are reported in chapters 5.1-5.5, while the last two chapters (5.6-5.7) are devoted to dissemination and governance aspects. When possible, a sectoral approach has been adopted to analyse the results of the visits, in accordance with the categories listed in Chapter 4.1 (Table 3).

Considerations on the feedback received from the beneficiaries about policy and economic aspects, namely the two most significant contributions to decision makers at European level for the preparation of new pieces of legislation on soils, are illustrated in Section 6.

5.1 Projects' sustainability

The verification of how, as well as to what extent, the project activities have been continued and the related outputs replicated, was one of the main objectives of the present study. Obviously, the success actually achieved differs from project to project and depends on multiple factors linked to the relevant sectoral context as well as the local policy framework. The highlights of the survey are presented below, while the information collected from each project is summarised in Table 4.

Among the projects of the agricultural sector, **DEMETER**, **FARMS 4 FUTURE**, **EUTROMED**, **Help SOIL** and **CarbOnFarm** are the ones which better transferred innovative good practices of soil protection/conservation, technologies and decision support tools to farmers, who are still using them in their daily activities. The fertilising and soilless substrates devised and tested by **Biorewit** are today sold in the shape of three distinct commercial products (https://sklep.poltops.pl/nawozy-ekologiczne-c-3.html). Therefore, the replication of these projects' results was satisfactory, far-reaching and effective with respect to soil conservation and improvement of overall fertility. In some cases, the use of agro-chemicals was also reduced due to the innovations introduced by the LIFE projects.

Technology for soil remediation from various kinds of chemical pollution and degradation, devised by **BIOREM**, **New LIFE** and **DISCOVERED LIFE**, is still in place and additional areas are being treated through these processes. Part of the remediated land is now cultivated.

LIFE SAM4CP and **SOS4LIFE** designed methods for assessing the impact of soil sealing in the urban environment. The tools devised by both projects to estimate the reduction of ecosystem services due to soil take are still in use by the relevant institutions, even though the tools are in need of an IT upgrade.

As for the projects of the land management sector, the restoration of degraded peatlands, started by **LIFE REstore**, is still ongoing as is that of **BIOREM**, while no significant replications have been registered for the projects **SOIL-Montana** (proposed practices not attractive enough for farmers) and **Soil Sustainability** (lack of financial resources).

Table 4. Sustainability table

PROJECT	CONTINUATION	REPLICATION
DEMETER	Although the beneficiary admits that the Demeter tool (a decision-support tool for recommending best nutrient and soil organic matter management to farmers) is presently outdated, as it requires upgrading on new agricultural techniques, during the ex-post visit it emerged that the number of users has increased after the project's end. To support the proper working of the tool, the coordinating beneficiary has employed an IT professional for its maintenance. In addition, the beneficiary is using components of the Demeter tool to develop a new tool for guiding farmers in carbon farming.	613 new users signed up to use the tool after the project's end. However, the tool is still only used by farmers in Flanders, because of language problems.
Crops for better soil	Sustainability of the project results is controversial, as some of the ecological farming practices recommended by the project were not eventually adopted by the organic farmers who had tested them. In addition, a number of farmers who converted to organic agriculture during the project (and with its support) left the certification system and went back to conventional farming because they found it unprofitable to continue practising organic agriculture. The two prototypes developed during the project for mapping soil quality were further improved during the after-LIFE period. However, the new versions were never used by the Spanish farmers because of the high costs of contracting the external service to run the devices.	None
EUTROMED	At the time of the ex-post visit, the solutions based on plant filters to retain excess nitrogen in shallow water and stabilise soil against erosion, devised by the project, were still in place and functional. The solutions require low maintenance and are durable. Farmers' expectations were fully met as the majority of gullies disappeared. In addition, the project demonstrated (at its end) that a reduction of 32% of the nitrogen applied to crops was attainable. Reportedly, vegetative cover of land, also promoted by the project during its life, is today quite extended among the olive farmers of the area.	After the project's end, its solutions have been replicated with success by two other projects, implemented locally. The beneficiary confirmed that currently around 80% of the Santa Mónica de Píñar Cooperative's farmers are implementing the vegetative coverage (on around 3,200 ha). Furthermore, this practice is also widely extended among other olive-growing farms, showing a significant change of behaviour of the farmers.
Biorewit	The sustainability of the project results is mainly associated with the production and sale, by a Polish private company, of the fertilising and soilless substrates devised and tested by the project.	It is estimated that during 2022 the company will produce about 72 tons of eco-activators and about 50,000 m3 of soilless substrates, in the shape of three distinct commercial products.
LIFE+Farms for the future	The project's results are partly continued by the beneficiary in four new projects, where the issue of soil and water pollution linked to appropriate livestock and manuring management is being tackled. The research on catch crops is also continuing in one of the four projects, however, farmers are seldom interested in growing such plants because this entails expenditure not immediately compensated for an increase of production/income.	In terms of replication, use of the conductivity meter for controlling the amount of nutrients added to the soil through the spreading of pig slurry has become a successful practice. Thanks to this, today livestock breeders can supply a known quantity of nitrogen to farmers through the slurry, which makes the latter fully aware of the actual amount of nutrients they add to the soil. In addition, use of the conductivity meter for applying manure with tank tractors became obligatory in Catalonia from 2019. Due to this, replication is occurring on nearly 315,000 ha.

PROJECT	CONTINUATION	REPLICATION
Help SOIL	The main sustainable agricultural practices are still in use in 19 of the original 20 demo farms, located in four regions of northern Italy. The continuation of these activities has also been supported by regional actions financed by the European Agricultural Fund for Rural Development (EAFRD). This financial support for farmers was crucial to maintain the conservation approach adopted in the project.	Replication is ensured by the fact that the project's soil conservation practices were included in the regional rural development plans of the five regions that participated in the project. Overall, about 90,000 ha were expected to be farmed in the five regions using the project's good practices in 2022. Over the same period, 10 more Italian regions launched similar actions in their regional plans and, as a result, around 200,000 ha were expected to be managed using soil conservation practices by the end of 2022. In particular, in the Emilia-Romagna region, the project's results are being replicated in 15 farms of hilly areas through the project LIFE agriculture (LIFE18 CCM/IT/001093).
CarbOnFarm	The sustainability of the project's results is maintained through the continued production of green compost by the prototype plant, built by the project at the premises of the AB PRIMA LUCE (which is a member of the producer organisation Terra Amore). The compost is then spread on the farmers' fields, on an average area of 50 ha every year. A minor portion is used for making 'compost tea'. Green compost production continues in a large biodynamic farm that participated in the project's trials. Lastly, a field trial on maize is being continued by the beneficiary at its experimental farm in Castel Volturno, with the purpose of assessing the long-term effect of the compost on soil quality.	Thanks to the project outcomes, the local consortium Terra Amore is increasing the organic farming area in Campania (southern Italy) and is relying more and more on organic fertilisation, thus drastically reducing the use of mineral fertilisers and pesticides. The project's composting technology has been replicated in Basilicata and Campania, where nine new on-farm composting units were created. The methodology of producing green compost and its use in agriculture was replicated in a research project financed by the European joint programme SOIL.
Soil Sustainability (So.S)	The soil protection action plan (SAP) devised by the project for the water basin of Anthemountas (Greece) has not actually been implemented by the municipalities concerned after the project's end, due to lack of funds and reciprocal coordination. The SAP was however appreciated by the interested farmer communities, which applied some of the plan's measures on farm, obtaining benefits in terms of soil protection and better crop productivity.	None
SOIL-Montana	The methodology for assessing agricultural systems' status in terms of biodiversity and soil conservation (namely, the Agroecosystem Health Cards - TSAs) was included by the beneficiary in three ongoing projects at national and EU level. However, this tool was not appreciated by the majority of livestock breeders. After the project's conclusion, those who were involved in the project did not continue using the TSAs and there was no demand from other livestock breeders.	None
BIOREM	The project's activities are still in place at one site in Italy, on 10 ha: the conversion period ended in 2020 and since then the land has been cultivated, showing the effectiveness of the restoration process devised by the project. In Spain, the areas under the project's treatment have increased, reaching 80 ha.	The project's results have been replicated in five applied research projects in Italy and Spain.
SelPiBioLife	Selective thinning was recognised as valid by the forest law of the Tuscany region right after the end of the project. This method can therefore be applied after a forest owner has justified its use in a specific technical report, as specified by the law. This outcome can be considered as a sign of the project's sustainability, but without a real impact on soil biodiversity.	The original activities had not been replicated at the time of the ex-post visit. However, through the continuation of the monitoring plots and the demonstration areas, plus the legal acknowledgement, the project created the conditions for its replication.
LIFE REstore	The five demo sites are still active: the beneficiary continues to monitor them in order to assess the effect, in the mid-term, of the various afforestation activities for the recovery of degraded peatlands.	The company in charge of peat extraction, owner of two of the project's five test sites, also applied the project's solutions in its former peat extraction fields: an area of 13.2 ha overall (22,000 pines planted).

PROJECT	CONTINUATION	REPLICATION
MEDAPHON	The monitoring system, based on the development of a specific tool for detecting soil-living microarthropods as indicators of soil health, has never been commercialised because it soon became outdated. However, the next generation of the tool was under development at the time of the ex-post visit and it is already close to market uptake.	None
NorthPestClean	Sustainability is linked to the knowledge, gained during the project, on the reaction of the pollutants (ethyl and methyl parathion and mercury) to the methods tested for eliminating them from soils. Further clean-up methods of other Danish heavily polluted areas are now likely to be developed, starting from the project's findings.	None
New LIFE	The technology developed by the project to reclaim degraded soils has proven to be successful. The soil degradation tackled was due to compaction, loss of structure, lack of organic matter and sealing.	Due to the effectiveness of the technology, it is being replicated in four areas (on 53 ha in total) with serious soil degradation problems.
BIOXISOIL	The project's activities were not continued at the project site during the after-LIFE period. No monitoring actions of the mid-term effects of the project's methods of land remediation were carried out after the project's end. The method of bioremediation with native bacteria and phytoremediation eventually provided satisfactory results. Unfortunately, in 2021 this area was excavated by the owner, hence no further results are available to evaluate whether the site has been fully remediated or otherwise.	The three techniques used by the project at the test site were replicated, at pilot scale, in other Spanish sites during the period 2018-2021.
DISCOVERED LIFE	After the good results achieved by the project at its end, the beneficiary decided to continue applying the remediation method, from the original pilot scale to extended scale, in order to treat the whole polluted industrial area of Bailín. According to the strategic plan of the Government of Aragon, remediation works will continue until 2040. Since 2019, a new LIFE project has been implemented at the Bailín site to find a solution for treating the source of pollutants targeted by the DISCOVERED LIFE project.	None for the time being, but the beneficiary is going to apply the project's results at another polluted site.
LIFE ReSoil	Demonstration and further development of the soil remediation technology have been continued by the beneficiary. The pilot plant constructed by the project is still operational, but, in the after-LIFE phase, it has been used only a few times to test the technology for different types of soils and pollutants. Although it proved efficacious at pilot scale, the beneficiary has not yet been able to commercialise the novel technology because of the high costs.	In order to compete in a public tender, launched by Horizon 2020, the beneficiary manufactured a small-scale mobile soil remediation unit, for testing the technology's suitability at the site of the contaminated soil, thus avoiding costly transport of soil to the original pilot plant. In the end, the beneficiary did not win the tender, but the unit is currently being used to demonstrate the technology for remediation of different types of contaminated soils.
LIFE SAM4CP	The methodology for quantifying the eco-services that soil provides and the monetary value of those services is still valid and in use by the beneficiary. However, the model devised by the beneficiary Simulsoil for quantifying the costs of land uptake (i.e. the reduction of natural capital) is outdated, together with the associated database.	Simulsoil's concept has been incorporated in the Soil4LIFE project, and successfully used for implementing case studies on the municipalities of Rome and Milan.

PROJECT	CONTINUATION	REPLICATION
SOS4LIFE	The methodologies developed by SOS4LIFE are being used by the municipalities involved in the project (Forlì, Carpi and San Lazzaro di Savena) to fulfil the objectives set in the regional law 24/2017, enacted by the Emilia-Romagna region, namely, reduction of land uptake by 60% at municipal level and revision of existing urban plans, to make cities more resilient to climate change. Soil de-sealing interventions are ongoing too. The methodology to quantify the ecosystem services provided by soils has been used by the AB Regione Emilia-Romagna, after the project's end, to map all of the regional territory.	Since the regional law 24/2017 recommends taking the ecosystem services into due consideration during the decision-making process for urban planning, more than 100 municipalities have already adopted this approach and requested, from the region, maps of the ecosystem services of their territories.

5.2 Threats and pressures

In general, the projects defined the pressures well and had mostly put in place actions to address them within their original timeframe, but further constraints often emerged in the after-LIFE period that impeded, or at least reduced, replication of the project outputs. The pressures highlighted by the beneficiaries during the ex-post visits are summarised in Table 5 below.

Table 5. Threats

PROJECTS	SECTOR	THREATS
EUTROMED **DEMETER**	Agriculture	Reluctance of farmers to introduce innovative solutions in their daily activities, especially if those practices are not directly linked to production.
Crops for better soil		Insecurity of farmers in coping with extreme weather events, coupled with uncertainty caused by the implementation of new agricultural methods (organic farming). Need of specialised technical support. High risks of poor economic performance when dealing with the organic method which is reportedly linked to a lack of adequate market channels for the commercialisation of organic products.
Help SOIL		Limited availability of specific machinery for preparing the soil and sowing, as required by the project's protocols.
Soil Sustainability (So.S)	Land management	Lack of an institutional and regulatory framework dealing with soil management. Lack of funding for implementation of the measures proposed by the project (soil protection action plan) and approved by the municipalities of the area of intervention.
BIOREM		High implementation cost of the strategy to remediate and monitor soil conditions. This can prevent large-scale adoption of the proposed approach.
LIFE REstore		Increased incidence of extreme weather events that might disrupt the restoration measures, based on revegetation interventions.
NorthPestClean	Remediation	Presently, the effect of climate change (e.g. rising ground water and sea levels) is a threat for the area as the depot with toxic materials is located near the sea and may be impacted both by wave erosion and by the rising ground water level.
New LIFE		The use of organic waste for reconstitution of soils implies legal prescriptions and a lengthy process to obtain permits from local authorities.
DISCOVERED LIFE		The main threat to effective implementation of the project's results is represented by the heterogeneity and complexity of the polluted aquifer in the relevant area.
LIFE ReSoil		Specific remediation goals set by local legislation as upper limits of some chemicals cannot be achieved through the project's technology. Different procedures to obtain environmental authorisations in each country.
SOS4LIFE	Urban planning	Lengthy bureaucratic procedures for de-sealing interventions and, above all, the constantly increasing cost of the pertaining works (demolition, earth moving, greening, etc.).

As expected, for the beneficiaries of the agricultural projects, one of the main threats to the continuation of the solutions devised lies in the traditional reluctance of farmers to introduce innovative solutions in their daily activities, especially if these practices are not directly linked to production and income. Also, problems with local markets emerged during the visits, as the beneficiaries highlighted the fact that it is hard to find the specific machinery necessary to carry out the sustainable practices on farmlands and, at the same time, some particular types of agricultural products resulting from innovative cultivation systems (organic products, cover crops, etc.) are not easily commercialised.

The high investment costs of implementing the proposed technologies (combined with a lack of funds for stakeholders willing to do so) is particularly relevant for the projects in the remediation sector, while the lengthy bureaucratic procedures for obtaining permits from local authorities is a constraint common to multiple sectors. Besides simpler and faster procedures to obtain the required permits, a more direct integration with the European Structural and Investment Funds could also be useful to further promote remediation activities at EU level.

5.3 Soil monitoring

Ensuring continuity in monitoring activities is a key factor for long-term success of soil-related projects and policy-driven actions. Indeed, the effectiveness of different policies on soil health can only be assessed by surveying changes in indicators that capture the condition of soils to supply ecosystem services or the broad range of pressures that compromise soil functions. Overall, the results achieved by the projects involved in the ex-post study depend on the type of environmental issues targeted and on the ability of the beneficiaries to develop synergies at local level.

As for the remediation sector, four projects out of five have continued monitoring the sites where the original decontamination activities were implemented. Beyond the pedological aspects, the projects **DISCOVERED LIFE** and **NorthPestClean** are also carrying out hydrogeological monitoring of the polluted areas: the latter's activities are actually implemented within the LIFE project Coast to Coast Climate Challenge (LIFE15 IPC/DK/000006).

Figure 1. *Old Bailín landfill (ES) in which the DISCOVERED LIFE actions have been carried out*

In those projects not focused on improvement of a single area, continuation of the monitoring activities was more problematic, as surveys of extensive areas are more expensive and require more complex organisation to collect and harmonise the data. Thus, the project **Soil Sustainability** developed a well-structured plan to monitor the main soil threats in the Anthemountas river basin area (Greece), but this was not implemented due to a lack of financial resources. Soil and other environmental parameters (e.g. GHG emissions, vegetation, etc.) are being monitored in the demo sites of the projects **BIOREM** (Italy) and **LIFE REstore** (Latvia), but these only cover areas with a limited extension and with a demonstration character.

A well-defined strategy for large-scale monitoring has been developed by the project **DEMETER** in Flanders (Belgium). A network of almost 2,600 plots called Cmon was launched in 2021 and will measure the organic carbon content in cultivated soil: determination of the baselines and then every 10 years.

In the agricultural sector, two Italian beneficiaries (Regione Lombardia and Regione Veneto) of the project **Help SOIL** have continued monitoring the soils of the farms involved in the implementation of sustainable practices, but in a sporadic way and only when supported by other local initiatives or projects. In the project CarbOnFarm, the associated beneficiary Prima Luce is monitoring (on a two-year basis) the organic matter content in the 20 farmlands of the consortium Terra Amore (located in southern Italy), as a result of the regular application of green compost produced internally by the associated farms.

In the framework of the **SOS4LIFE** project, the land uptake at regional level is being monitored by the associated beneficiary Regione Emilia-Romagna through the geo-referenced database (Urban and Soil Decision Support System) developed during the project. This tool needs to be frequently updated with new territorial data, but is still active and being used by technicians of the Emilia-Romagna region.

The EDAPHOLOG tool designed by the project **MEDAPHON** to assess the biodiversity in soils (in particular, microarthropods) was applied in 25 plots in Hungary for one year after the project's end (2012). The monitoring was remotely controlled through probes equipped with a logger device. The system is no longer operational as an upgraded version of the tool is being developed by the beneficiary with the support of international research centres (expected to be on the market by 2023). But the project can be considered as a significant example of how to survey soil biodiversity and, therefore, the spread of similar monitoring systems should be fostered at EU level.

5.4 Climate change benefits

Most of the evaluated projects did not foresee any measurement of climate benefits, neither at the end of the project nor during the after-LIFE period, as an effect of the results achieved. A minor amount of projects monitored the carbon fluxes during the projects' duration only. This is due to the fact that, until recently, the possible contribution of soils to the mitigation of climate change was not well known even among environmental experts. For this reason, the older LIFE projects did not always take due account of this important aspect. Nonetheless, for some it was possible to collect some significant information and data related to the post-LIFE activities implemented by the project that can be linked to climate change benefits.

The application of sustainable practices in farmlands supported by the project **Help SOIL** help to increase organic matter in soils and its conservation over a long-term period (thanks to the no-tillage approach). As a result, during the after-LIFE period, the beneficiaries estimate that about 90,000 tons of organic carbon will be stored in the soils of the farms (in the Italian regions of Lombardy, Veneto, Emilia-Romagna and Friuli-Venezia Giulia) that are implementing the conservation practices and are contractually committed to maintaining them over the next 6 years (as foreseen by the regional actions linked to the EAFRD). This corresponds to around 60 tons of CO_2 eq/km^2/year saved. The participants also highlighted that *certification* of the

environmental benefits (e.g. carbon credits and 'sustainable certification' for agricultural products or carbon farming) would be an effective instrument to support the farmers financially and further spread the sustainable techniques in other agricultural areas.

The LCA study, carried out after the end of the **CarbOnFarm** project, on the agricultural production process based on the use of 'on-farm' green compost, showed that CO_2 emissions are reduced by 18% per hectare as compared to the same crop cultivated with traditional systems. The soil organic matter content increased by the same rate.

One of the conclusions of the **LIFE REstore** project is that the real GHG emissions in peatlands in Latvia are lower than previously thought. The results of GHG emissions measurements within the project showed that the actual GHG emissions from managed peatlands in Latvia are significantly lower – up to two times lower – than the emission factors determined according to the IPCC methodology used in Latvian GHG inventory reports. However, this conclusion is questionable, as the methodology used for the measurements is not in line with international scientific standards and should be verified by an independent third party, as suggested in the specific review prepared by Jan Sliva (NEEMO) and submitted to CINEA on 17 November 2022.

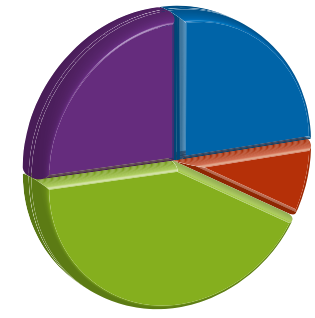
GHG emissions were also measured in the project **BIOREM**, which obtained an increase of organic carbon in soils through a remediation process that entailed in situ humification with organic waste.

As for the adaptation aspects, the climatic characterisation carried out by the **SOS4LIFE** project, before and after the de-sealing activities, highlighted a decrease of the air temperature and an increase of the comfort index for citizens living in the surroundings of the area of intervention.

5.5 Stage of development of technologies/methodologies

Most of the projects involved in the study did not actually develop new technologies. Rather, they tested innovative methodologies or improved management practices that already existed. The current stage of development of these technologies/methods has been ranked by the TMOs after the ex-post visits according to the six following scoring categories: outdated, without prospects, still uncertain, promising, technically/economically proven, and established.

Technologies/Methods



The methods devised by the projects **DEMETER, MEDAPHON** and **NorthPestClean** were promising during the projects' lifetimes, but afterwards became outdated and therefore **upgrades** are currently ongoing. In particular, the new version of the **EDAPHOLOG** instrument, developed by the **MEDAPHON** project to monitor arthropods in soils, is expected to be ready by the end of 2023. The remediation method, based on alkaline hydrolysis, developed by the project **NorthPestClean** is still to be improved in order to deal with mercury pollution, while two IT tools for farmers are being developed by the project **DEMETER** (to define a soil and water management plan and to measure carbon stocks at farm level) to upgrade the existing IT platform.

At the time of the ex-post visit, the technology developed by the project **LIFE ReSoil** (mobile unit for soil washing at large-scale level) was assessed as **promising**, while those developed by **EUTROMED** (vegetation weirs), **Help SOIL** (soil management systems), **CarbOnFarm** (in-farm composting), **BIOREM** (plant and organic waste-based restoration) and **BIOXISOIL** (ISCO and phytoremediation) have reached the status of **technically proven**.

Lastly, the technologies devised by the projects **Biorewit**, **New LIFE** and **DISCOVERED LIFE** have achieved the higher status of **established** and are available on the market.

5.6 Planning and governance

Inclusion of the project outputs in local plans is a useful way to ensure effective implementation of measures designed to improve conservation of soils. Actually, projects have not all had the opportunity to integrate their results in local plans, nonetheless some significant collaborations with regional authorities for the organisation of programmes and long-term actions addressing soil issues can be mentioned.

Among the projects dealing with soil remediation, it should be noted that the ISCO technique, tested by the project **DISCOVERED LIFE**, has been included in the strategic plan of the Government of Aragon (Spain) to reclaim industrial areas polluted by lindane (a substance used for the production of insecticides). Similarly, the results of the project **NorthPestClean** have been used by the Central Denmark Region to plan cleaning of the area where the project solutions were tested as part of a programme for remediation of the 10 most polluted sites in Denmark.

Figure 2.
The Groyne 42 site: not much reveals that this is one of the 10 most seriously polluted areas in Denmark

Among the agricultural sector projects, **Help SOIL** had the most effective connections with local plans. In more detail, the proposed sustainable agricultural practices have been included in the regional plans linked to the EAFRD. Each Italian region involved in the project (Lombardy, Veneto, Emilia-Romagna and Friuli-Venezia Giulia) launched specific actions through the EAFRD to financially support farmers that adopted soil conservation techniques. For this reason, it was possible to extensively replicate the project activities to over 485,000 ha in Lombardy.

In the Basilicata region (Italy), the project **CarbOnFarm** developed connections with the Rural Development Plan (2014-2022), as the compost produced by the beneficiary has been tested by one operational group to produce a liquid fertiliser from local compost which was applied on strawberry fields to mitigate the loss of fertility.

The Catalonia region (Spain) approved Decree 153/2019 for managing fertilisation through livestock manure and approved an action plan for vulnerable areas of agricultural origin. This plan includes the obligation of using one of the best practices for manure application tested within the project **FARMS 4 FUTURE**, namely, the use of a conductivimeter to estimate the amount of nutrients.

The inventory of degraded peatlands, as well as the calculation method for measuring GHG emissions from peats, prepared by the project **LIFE REstore**, was used by the Latvian Cabinet of Ministers to define the Territorial Just Transition Plan in July 2022 (see comment on the reliability of project conclusions in Chapter 5.4).

Lastly, it is worth mentioning that the tools developed by the projects **LIFE SAM4CP** and **SOS4LIFE** are being adopted by municipalities of two Italian regions to support the preparation of their new General Urban Plans (Piano Urbanistico Generale – PUG – in Italy) in order to reduce the land take at local level.

Other projects' outputs could provide a useful contribution for the implementation of local plans, such as **Soil Sustainability** for the management of water basins in Greece, but no significant policy uptake results have been achieved so far. In other cases, the solutions proposed by the projects are only recommended in local plans, but since they are not supported by a legal requirement for applicants/users, they are not extensively implemented.

5.7 Community engagement and dissemination

Seeing the general lack of awareness on soil issues at various levels (from scientists/technicians to ordinary citizens), engagement with stakeholders should be considered as a crucial aspect to ensure continuation of the projects' activities. Indeed, the most common stakeholder interactions across the projects were with research entities and the relevant public authorities.

The agricultural sector projects have been quite active in involving stakeholders, as direct contacts are deemed essential to disseminate innovations among farmers. The key factor for the success of these initiatives was networking with other local projects or events that ensured the required financial resources. In this regard, the monitoring team had the opportunity to attend an on-field training session during the ex-post visit to the project **FARMS 4 FUTURE**: the event was organised in collaboration with the project LIFE AGRICLOSE (LIFE17 ENV/ES/000439).

Figure 3.
Training of young farmers in Castelló de Farfanya (ES)

In the after-LIFE period, the same project (FARMS 4 FUTURE) also organised two seminars per year as well as two training courses on sustainable fertilisation, and a protocol for improving soil mapping is expected to be published in 2023. Technical seminars for farmers and local stakeholders have also been organised by the beneficiaries of the project **EUTROMED** in four Spanish municipalities.

The beneficiaries of the project **Help SOIL** have engaged regional stakeholders through the establishment of Operative Groups for Innovation (Gruppo Operativo per l'Innovazione – GOI – in Italian) which put farmers in contact with research institutions to increase the diffusion of scientific knowledge in the agricultural sector.

Significant collaboration with local policy stakeholders has been developed by the project **Soil Sustainability**. Guidelines prepared by the beneficiaries to prevent soil sealing and erosion have been integrated in the training material of the continued training programme for public servants in the Central Macedonia region (Greece).

The project **DISCOVERED LIFE** involved stakeholders through the establishment of two types of committee to follow the activities for decontamination of soils polluted by lindane in Aragon (Spain): the *Institutional Committee* composed of public stakeholders (municipalities of the Gállego river basin, the Ebro Water Confederation, Aragon Water Institute, civil defence, public health, the Government of Aragon) and the *Social Committee* (composed of agricultural associations, ecologists, political parties, etc.). The members of these committees organise a meeting at least once a year.

Since the end of the project **LIFE REstore**, the demo site Kaigu mire has been visited by around 100 people every year – mainly students from the University of Latvia as well as experts and representatives from different institutions and organisations. At the same time, at least 190 people have visited the demo site in Kemeri (Latvia) where sphagnum planting took place. Representatives from the Lithuanian Fund for Nature visited the site and then planted sphagnum in the Aukštumala bog in Lithuania within another project, LIFE Peat Restore (LIFE15 CCM/DE/000138).

Figure 4.
Demo site in Kemeri (LV) visited by stakeholders

The project **NorthPestClean** has involved stakeholders in the use of a tool to define decontamination scenarios

(https://www.northpestclean.dk/siteassets/northpestclean/publikationer/npc/2014/2014-07-03-baredygtighedsvurdering-af-losningsalternativer-for-hofde-42-02-07-2014.pdf). The methodology is based on assessment of the following aspects: a) effect, b) economy, c) time, d) environment and e) society. After the LIFE project, the tool was used in a process involving authorities, experts and the general public to select the best remediation approach.

One of the more interesting communication products created in the post-LIFE period is a video filmed by the project **SOS4LIFE** that recorded the steps necessary for implementation of de-sealing operations: removal of pavement and concrete structures, laying down of new soil, and greening of the area. The video is available on the project's YouTube channel: https://www.youtube.com/watch?v=W4s7pNNjkSQ.

Figure 5.
Demo site in Forlì (IT) before, during and after the de-sealing intervention

5.7.1 Websites

The project websites are effective IT tools to showcase after-LIFE activities. Projects are contractually bound to keep their websites active after project closure, but most of those involved in the ex-post study were concluded more than 5 years ago and thus this obligation is no longer valid. As a result, 13 websites are still accessible (but not updated), 5 are closed and 2 are being regularly updated.

The tool developed by the project **DEMETER** for sustainable fertilisation of farmlands is still available online and working (https://eloket.vlm.be/Demeter/Account/LogOn). Also, the open-access database of degraded peatlands affected by peat extraction, developed by the project **LIFE REstore**, is still available (https://ozols.gov.lv/kartes/apps/MapSeries/index.html?appid=5e96f7ecdf8e40929d3b4928eab6e21e).

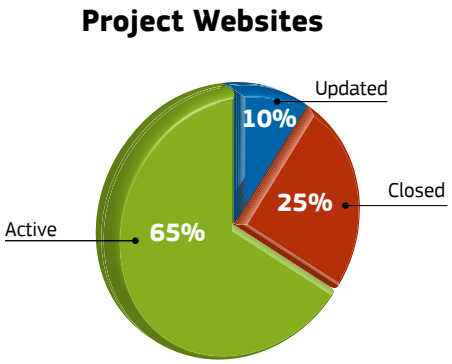


Figure 6.
LIFE DEMETER online tool

It should be noted that the project **Help SOIL**'s website (http://www.helpsoil.eu) has been very successful: it is still active (although 5 years have already elapsed) and continues to draw interest from the audience, especially agricultural sector stakeholders. More than 30,000 visitors per year have been registered after the project's end and therefore the beneficiaries intend to keep it updated in the coming years.

Figure 7.
Help SOIL website updated by Regione Lombardia

6 Final assessments

This section includes more comprehensive evaluations in terms of environmental, policy and socio-economic impacts obtained by the selected projects during the after-LIFE period. This is based on the information and data collected by the monitors during the visits and further elaborated by the coordinator of the soil ex-post study.

6.1 Environmental impacts and KPIs

The quantification of the actual ex-post environmental and climate impacts, in agreement with the indicators set in the LIFE KPI database currently used to monitor LIFE 2014-2020 projects, was one of the objectives of this study. As the compilation of KPIs was not mandatory within the LIFE+ programme, the task was quite complex, and the data obtained was not always aligned with the requirements set for ongoing projects.

The two **2014-2020** projects – SOS4LIFE and LIFE REstore – involved in the soil ex-post study already filled in the LIFE KPI database at the time of submission of the final report and the related values have been confirmed during the pertaining ex-post visits. In particular, the SOS4LIFE project, one of two projects falling in the **urban planning sector**, confirmed the benefits in terms of reduction of the expected soil sealing (around 100 ha), thanks to the revision of municipal urban plans related to three municipalities of the Emilia-Romagna region (Italy) and to the foreseen de-sealing interventions.

The **agricultural sector** projects mainly addressed the issue related to *organic matter* content in soils, as well as the loss of soil due to compaction and erosion, thanks to the implementation of sustainable agricultural practices. In particular, through the Help SOIL project, the organic matter content has increased over about 36,000 ha of arable lands in Lombardy (Italy) since the start of the project (2013). The rate of the increase is not homogenous (estimated in the range of 0.02-0.76 tons/ha/year) as it depends on the type of practice adopted, the type of soil and the meteorological conditions over the years. It should be noted that this benefit is not ensured for the future as it implies continuation of the sustainable practices in the farms: possible modifications to the cultivation systems may significantly alter the organic matter content in the soils.

Also, the EUTROMED project achieved significant results over more than 4,400 ha in terms of reduction of soil *erosion* in Spanish olive groves (Granada, Montes Orientales region) through the use of vegetation weirs. The beneficiaries estimated a saving in soil loss that varies from 12.14 tons/ha/year to 48.57 tons/ha/year: it depends on the severity of the erosion affecting different parts of the area of intervention.

As for the **restoration/land management sector**, the soil issues targeted are varied as the areas of interest have different types of use (forests, agro-systems, peatlands, etc.) and different geomorphologic characteristics. In this regard, BIOREM can be considered as the more representative project, as the beneficiaries restored around 90 ha of degraded and semi-arid areas in Italy and Spain during the after-LIFE period through the use of organic waste and plantations. The increase of *fertility* and improvement of the water retention capacity laid the groundwork for renaturation of the areas and also the partial conversion to agricultural use.

The Latvian project LIFE REstore represents an interesting case for the assessment of climate change impacts related to management of organic soils. According to the test carried out by the project, the most effective method to reduce ***GHG emissions*** from degraded peatlands is afforestation (-3.58 tons/ha/year of CO_2 eq), while renaturation through introduction of mosses in aquatic conditions generates an increase of GHG emissions (+3.80 tons/ha/year of CO_2 eq). These data are of considerable interest but at the same time questionable because they are not in line with general scientific knowledge in the sector. As already mentioned in Chapter 5.4, the project's conclusions on GHG emissions are controversial, even though they were used by Latvian national authorities for various policy documents. A review by independent experts and a thorough analysis of the results, when available, of two similar projects, LIFE OrgBalt (LIFE18 CCM/LV/001158) and LIFE PeatCarbon (LIFE21 CCM/LV/004396), are advisable.

Also, a more detailed survey on the characteristics of the organic soils (type and depth of the layers) resulting from the different types of management should be carried out, in order to provide a more complete picture of the pertaining environmental impacts.

The **remediation** projects addressed various types of soil ***contamination***, such as hydrocarbons, heavy metals and pesticides. Unfortunately, the decontamination systems proposed by the projects, although technically effective, have not been replicated due to various reasons (i.e. high costs, complex authorisations needed, etc.). For this reason, the projects that have generated the most significant impacts are those that successfully completed reclamation of the original areas of intervention, namely BIOXISOIL (1.5 ha included in a military site) and New LIFE (10 ha included in a regional river park). The former was implemented over an area polluted by hydrocarbons and the latter over a completely sterile soil covering a closed landfill.

Overall, 8 ***LIFE+*** projects (out of 18) have managed to provide, during the ex-post missions, adequate and consistent data to be uploaded to the LIFE KPI database. All the values are related to the indicator '4.3 Resource efficiency – soil' and are expressed as a reduction of the area affected by a certain type of environmental issue (descriptor), as foreseen by the methodology adopted for the LIFE 2014-2020 projects. The results are summed up in the table below and will be included in the LIFE KPI database.

Table 6. KPI values collected during the visits

PROJECT	INDICATOR	DESCRIPTOR	UNIT	VALUE		
				Before project	End of project	+2 years after project
BIOREM	4.3 Resource efficiency – soil	Desertification	ha	90	89	0
New LIFE	4.3 Resource Efficiency – soil	Soil compaction	ha	20	10	10
BIOXISOIL	4.3 Resource Efficiency – soil	Local contamination	ha	1.5	0	0
Farm 4 Future	4.3 Resource Efficiency – soil	Diffuse contamination	ha	850,000	849,200	540,000
EUTROMED	4.3 Resource Efficiency – soil	Soil erosion	ha	49,427	49,057	45,018
CarbOnFarm	4.3 Resource Efficiency – soil	Organic matter	ha	90	10	5
Help SOIL	4.3 Resource Efficiency – soil	Organic matter	ha	521,200	521,195	485,092
LIFE SAM4CP	4.3 Resource Efficiency – soil	Soil sealing	ha	3,289	3,024	2,861

6.2 Policy impacts

Positive impacts in terms of achievement of the policy goals have been registered in several projects (even if, in some cases, the quantitative contribution is quite modest), while only a fraction of the projects produced a significant contribution to the new directive on soils. The results of the ex-post survey are illustrated in the following paragraphs.

6.2.1 Policy implementation at EU, national and local level

At *European level*, most of the projects had among their main objectives supporting the implementation of the old EU soil thematic strategy (Communication COM (2002) 179 and COM (2006) 231, which was the main piece of European legislation devoted to the protection of soils. Yet, the objectives of the new EU soil strategy for 2030 are fully in line with the previous one, and the main soil issues to be addressed are the same (but with more emphasis on the climate change benefits linked to soils). The new EU strategy also entails more specific actions to be implemented by the EC and EU Member States (sections 3.1 to 4.4 of the official document) and, in this regard, there are some outputs achieved during the projects, and further developed in the after-LIFE period, that can be considered as useful contributions to achievement of these goals. These are as follows:

Soil for climate change mitigation and adaptation (3.1) – The LIFE REstore project (LIFE14 CCM/LV/001103) tested various systems to manage peatlands in Latvia and monitored the related GHG emissions. This should help to 'eliminate the anthropogenic emissions from organic soils' as stated in the EU strategy.

Soil and the circular economy (3.2) – The projects LIFE SAM4CP (LIFE13 ENV/IT/001218) and SOS4LIFE (LIFE15 ENV/IT/000225) developed systems to support implementation of the first point of the 'Hierarchy in land planning' (avoid, reuse, minimise, compensate), avoiding additional land take and soil sealing through the revision of local urban plans.

Soil biodiversity for human, animal and plant health (3.3) – The MEDAPHON project (LIFE08 ENV/H/000292) developed a field instrument to measure the main parameters of soil biota to assess microbiological activity and biodiversity in soils. This should step up efforts in mapping, assessing and protecting soil biodiversity as fostered by the EU soil strategy.

Soil for healthy water resources (3.4) – The project EUTROMED (LIFE10 ENV/ES/000511) promoted the use of plant-based weirs to filter nitrates, increase water infiltration and thus reduce the nitrogen content in groundwater as well as surface erosion. The So.S project (LIFE07 ENV/GR/000278) fostered several land management practices to address various soil issues affecting river basins in Greece. This can be considered as a useful example of integration between soil and water management and could be included in local basin and flood risk management plans.

Making sustainable soil management the new normal (4.1) – The projects Help SOIL (LIFE12 ENV/IT/000578) and LIFE+Farms for the future (LIFE12 ENV/ES/000647) promoted the use of various sustainable practices (no-tillage, cover crops, systems to optimise manure distribution, etc.) for arable lands. This contributes to the improvement of soil health in the agricultural sector where traditional intensive practices are responsible for fertility depletion, soil loss and an excess of nutrients in groundwaters.

After the collaborations developed in the framework of the Help SOIL project, the associated beneficiary ERSAF, in collaboration with two universities located in Lombardy (Italy), launched in spring 2022 a living lab called Innovative and sustainable models of soil management. This is one of the initiatives supported by the EU Mission 'A Soil Deal for Europe: 100 living labs and lighthouses to lead the transition towards healthy soils by 2030' within the framework of the Horizon Europe programme. This network is still at an early stage of implementation.

Preventing desertification (4.2) – The project SOIL-Montana (LIFE10 NAT/ES/000579) provided solutions to assess the health of agricultural ecosystems and thus prevent desertification in grazing areas under the Mediterranean climate, which are more sensitive to this type of soil threat. In addition, the project BIOREM (LIFE11 ENV/IT/000113) provided best practices (e.g. on-site humification and controlled revegetation) to recover degraded land and heavily exploited soils in areas of Spain and Italy subject to frequent drought conditions.

Restoring degraded soils and remediating contaminated sites (4.3/4.4) – The remediation of contaminated sites is addressed by several projects involved in the ex-post visits, such as NorthPestClean (LIFE 09 ENV/DK/000368), devoted to pesticide pollution, LIFE ReSoil (LIFE12 ENV/SI/000969), to heavy metal pollution, and DISCOVERED LIFE (LIFE12 ENV/ES/000761), to organochlorinated pollutants (insecticide). Although the technical solutions have been successful, their replication met some constraints due to the high costs of the proposed technologies.

An innovative solution to be taken into account for the restoration of severely degraded soils is that proposed by the project New LIFE (LIFE10 ENV/IT/000400). Actually, the New LIFE system creates 'new' soils starting from discarded mineral materials and organic waste and thus it has significant circular economy implications. The system can also facilitate the implementation of de-sealing interventions that usually imply the placement of soil coming from outside the sealed area (Chapter 3.2 of the EU soil strategy for 2030).

At *local and national level*, significant links between local legislation and the outputs of LIFE projects were developed in recent years. In particular, the following projects had a concrete influence on regulatory frameworks at regional level, leading to updates or revisions.

The project **LIFE+Farms for the future** (LIFE12 ENV/ES/000647) had a direct impact on regional policy – Government of Catalonia (Spain) – as one of the best practices tested by the project, namely, the use of a conductivimeter for spreading manure with tank tractors, is actually mandatory under Article 23 of Decree 153/2019 for managing fertilisation and livestock manure. The project was crucial to that end, as it was implemented while the programme for vulnerable areas due to nitrates of agricultural origin in Catalonia was under revision. It is also worth mentioning that the Government of Catalonia financially supports purchases of the project technology.

The urban planning approach proposed by the project **SOS4LIFE** is fully in line with the Emilia-Romagna regional law (LR 24/2017) on land planning which has adopted the European goal of zero net land take by 2050. As a result, the guidelines for modification of urban plans to reduce soil sealing (drawn up by the beneficiaries) have been officially adopted by three more municipalities: Bomporto, Nonantola and Zocca (near Modena, in Italy). In addition, since the regional law recommends taking **ecosystem services** into due consideration during the decision-making process for urban planning, more than 100 municipalities are adopting this approach and have requested the Emilia-Romagna region to prepare maps of ecosystem services related to their territories.

The area of intervention of the project **NorthPestClean** is 1 of the 10 main polluted sites in Denmark, the so-called generation pollution sites which were identified by the Danish Environmental Protection Agency and mapped by the regional authorities, as defined by Danish legislation on polluted soils (LBK nr 282 of 27/03/2017). The knowledge generated by the project and follow-up research were the basis for including the clean-up of the generation pollution sites in the Danish national budget for the period 2021 to 2025, entailing a total amount of DKK 630 million (€84 million) (ref. BEK nr 417 of 31/03/2022).

The project **CarbOnFarm** had an impact on implementation of the Common Market Organisation (CMO) Fruit and Vegetables (EU Regulation 1234/2007) in southern Italy. The largest national consortium of agricultural producers, Italia Ortofrutta, obtained from the pertaining European authority the eligibility of the costs for the on-farm composting units designed according to the layout developed by the project.

The coordinating beneficiary NEIKER (Basque Institute for Agricultural Research) of the project **SOIL-Montana** supported the drafting of the Basque Country Soil Protection Strategy 2030 which was published in June 2022 (https://www.ihobe.eus/publicaciones/estrategia-proteccion-suelo-2030). To this end, a soil assessment was carried out and NEIKER contributed to this with the results obtained from LIFE SOIL-Montana concerning soil biodiversity.

6.2.2 Policy issues and contributions to the forthcoming EU Soil Health Law

The agenda of the ex-post visits also included a discussion with beneficiaries and stakeholders about legislative barriers met by the projects and recommendations to improve the general objectives behind the ongoing regulatory tools. In particular, this was a useful occasion to figure out the beneficiaries' expectations of and possible contributions to the forthcoming EU Soil Health Law.

With only a few exceptions, all the people interviewed, especially those representing public entities or environmental associations, not only expressed their support for a European directive addressing soil protection issues, but also highlighted the fact that such a law is essential to stimulate the establishment of regulatory tools by the individual Member States to promote initiatives on soil conservation. As a matter of fact, most of the projects faced significant problems in replicating their initiatives, and one of the main reasons was the fact that there are very few *mandatory* regulations on soil protection at national level.

In this regard, the Greek project **Soil Sustainability (LIFE07 ENV/GR/000278)** emphasised that the lack of an integrated soil policy at national and EU level affected the project's sustainability, as the main activities were only occasionally implemented in the after-LIFE period by some of the beneficiaries, either for commercial purposes (e.g. soil reclamation sector) or for institutional missions (e.g. technical advice to farmers of the area).

The Italian project **LIFE SAM4CP (LIFE13 ENV/IT/001218)** regretted the fact that although the project outputs have been used by the associated beneficiary ISPRA to support the Italian government in designing legislation to prevent soil sealing, approval of the law is currently stalled in the Italian parliament. According to the beneficiaries, the launch of a European directive on soils would revive, and speed up, the related legislative process.

The project **BIOXISOIL (LIFE11 ENV/ES/000505)** remarked that the Spanish Royal Decree 9/2005 states that in-situ remediation practices are to be preferred above excavation and landfilling of polluted soils, but no authorisation is required for excavating and landfilling, and therefore these are the most common reclamation techniques in Spain. According to the beneficiaries, the forthcoming EU Soil Health Law should support the use of sustainable remediation systems so that all EU Member States will be pushed to define more strict rules for ex-situ techniques.

The private company that coordinated the project **New LIFE (LIFE10 ENV/IT/000400)** explained that the use of waste materials for regeneration of soils may imply very long permitting procedures and sometimes also opposition from the competent authorities on account of very strict rules. A more flexible approach in the legislation governing waste management for activities that have environmental implications is desirable and would facilitate replication of the innovative system developed by the project.

The Italian beneficiary **Legambiente** was involved in the project SOS4LIFE (LIFE15 ENV/IT/000225) and coordinated the project Soil4LIFE (LIFE17 GIE/IT/000477) where both concrete actions and awareness-raising initiatives on soil issues were implemented. In this context, Legambiente involved several environmental associations (33 European organisations from 10 countries) in the preparation of a position paper on the forthcoming EU Soil Health Law: this document was submitted to the EC and is available online (https://soil4life.eu/wp/wp-content/uploads/2022/06/Soil-position-paper_ENG_22-march-2022-1.pdf). In this position paper the following aspects are recommended:

- Support of the proposed soil health index to be used in land transactions.
- Public funding to monitor and assess the effectiveness of soil management practices included in the CAP payments.
- Mandatory targets at EU level for the conservation and protection of intact soils.
- Stop the outsourcing of soil degradation by reducing the ecological footprint of European imports that cause soil issues in other continents.
- Increase organic farming in rural areas and reclamation of contaminated/degraded sites.
- Update of the zero net land take by 2050 target by introducing intermediate binding milestones.
- Support the regeneration of soils through recycling of organic waste.

On the other hand, problematic positions towards an EU directive on soils also emerged during the ex-post study. In particular, the associated beneficiary the **Latvian Peat Association**, involved in the project LIFE REstore (LIFE14 CCM/LV/001103), provided a written contribution during the public consultation phase of the forthcoming EU Soil Health Law raising some concerns:

- Possible increase of administrative burdens or mandatory requirements, especially for peat extraction and the authorised exploitation of peatlands.
- The definitions of organic soil and peatland should be clear and cover all possible situations in various Member States.
- Potential controversies on the correct management of organic soils and degraded peatlands, as restoring waterlogged conditions does not seem to be the best solution in relation to the reduction of GHG emissions.

6.3 Socio-economic benefits

The technical monitors involved in the ex-post study also assessed the economic impacts of the project results and, if relevant, the market uptake of the technology/product/service developed. Actually, the economic benefits generated by the projects dealing with soil themes can be related to various actors, such as the users (of practices, technologies, etc.), or to wider communities (at any level). For this reason, the information obtained is not homogenous and is related to different economic aspects (costs for application of the systems/methodologies, benefits generated in the pertaining productive sectors, market prices for the technology developed, etc). It should also be noted that in the LIFE+ projects the assessment and monitoring of socio-economic benefits were not always included in the technical proposals and therefore have been taken into account only by a few beneficiaries during the after-LIFE period.

In addition, the EU Soil Health Law impact assessment needs to address gaps in soil-related information, especially on costs and benefits of interventions towards healthy soils, and thus the monitors were requested to get feedback from the beneficiaries on quantitative and qualitative economic impacts concerning the project interventions.

As a result, 13 projects out of 20 provided quantitative estimations of economic impacts. Two quantitative assessments are related to the market prices of products (Biorewit) or an innovative monitoring tool (MEDAPHON); four are for the cost of remediation activities; three are on the savings achieved through sustainable practices in farms, such as farm composting (CarbOnFarm) and systems to avoid over-fertilisation (FARMS 4 FUTURE); two are related to the correct management of rural areas (Soil Sustainability and LIFE REstore); and two to the costs saved by municipalities by reducing soil sealing in urban areas (e.g. SOS4LIFE).

Other projects have significant economic implications (e.g. Help SOIL for the agricultural sector and BIOXISOIL for the remediation sector), but detailed and reliable estimations are not available. This is due to the fact that, in some cases, an accurate estimation may require specific socio-economic studies that the beneficiaries are not able to carry out without an external contribution, or because the replication context is not yet sufficiently clear and thus the stakeholders of the related sectors have not supported a detailed cost-benefit analysis.

6.4 Successful projects and case studies

In this section, three successful projects in terms of sustainability are showcased. These projects were selected because they continued to have significant impacts after the end of LIFE funding. They can be taken into account as generic case studies for the relevance of the soil theme, the innovations proposed and the networking created with the stakeholders. A short description of the motivations that led to their selection is included in the following table.

Table 7. Case studies

PROJECT	ACRONYM	SECTOR	MOTIVATIONS
LIFE10 ENV/ IT/000400	New LIFE	Soil remediation	The project developed an innovative system for the restoration and reconstruction of highly degraded soils and showed a great replicability potential as well as interesting circular economy implications linked to the use of organic waste. Moreover, the related costs are not very high. At laboratory level, the project outcomes have also been exploited in the more recent project LIFE Agrised (LIFE17 ENV/IT/000269).
LIFE12 ENV/ IT/000578	Help SOIL	Sustainable agriculture	The project can be showcased as a good example of environmental objectives achieved at local level through the network developed between public bodies (regions), farmers and researchers in the agricultural sector. The fact that the activities have been successfully replicated thanks to links to the Rural Development Funds and CAP is of special interest and should be taken as an example for similar initiatives at EU level.
LIFE15 ENV/ IT/000225	SOS4LIFE	Soil sealing	The project provided significant examples and supporting instruments to implement de-sealing initiatives at municipal level. The tools developed by the project for public entities to reach European objectives in terms of prevention of land uptake have a strong replicability potential. The same approach has been adopted in one action of the more recent project Soil4LIFE (LIFE17 GIE/IT/000477).

7 Conclusions and recommendations

Despite the fact that the LIFE soil ex-post study was focused on only 20 projects, a large variety of topics have been assessed throughout this study which enabled the collection of interesting data on policy, environmental and socio-economic impacts generated by the projects. Analysis of the feedback received allowed the sustainability of project ideas to be assessed and the results after the end of EU funding to be quantified. General considerations on the main aspects included in the study are reported hereafter, while details on the results achieved by the individual projects are available in the previous chapters.

Overall, the ex-post study showed that the LIFE programme worked as a successful catalyst for innovation and diffusion of solutions providing environmental and socio-economic benefits, fostering implementation of the EU policy framework devoted to soil health. However, the extent of the impacts varies significantly according to the type and size of project, the targeted sector, and the ability of the beneficiaries to develop synergies at local level. In particular, the possibility to connect project outputs with local actors and/or ongoing sectoral plans was the key factor to guarantee replication of the project.

The **sustainability** of the projects in the ***agricultural sector*** was particularly ensured where local networks composed of farmers, technicians, research entities and public bodies were present on the reference territory. These networks are fundamental to promote the project outputs and promptly tackle farmers' needs during implementation of innovative agricultural techniques. Financial support from local authorities is crucial in the ***remediation sector***, since remediation and reclamation activities are inherently expensive, and even more so in the case of new reclamation systems, such as those tested by the LIFE projects. As for projects in the ***land management sector***, collaboration with similar initiatives or projects (including other LIFE projects) implemented in the same territories was also useful to support continuation of the project activities However, the experience gained by the beneficiaries showed that large-scale objectives can be accomplished only when the soil-related interventions are enforced by regional or national regulations covering specific or multisectoral themes (forestry, river basin management, habitat conservation, etc.).

As a result, most of the projects produced long **environmental impacts** but only some (around 35%) have really multiplied the benefits produced due to a successful replication or transfer beyond the project context. The main soil issues identified by the EU soil strategy (i.e. pollution, decrease of organic matter, erosion, sealing) have all been addressed by at least one project. However, in many cases, the related impact at sectoral level was rather mild, due to the limited size of the projects (inherently small for LIFE traditional projects) and a lack of continuous support from local authorities or stakeholders.

In addition, **climate benefits** can be taken into consideration as at least half of the projects have implemented methodologies to improve the carbon stock in soils. Yet, not all beneficiaries were fully aware of the contribution of soil to mitigating climate change issues and only a few provided robust data in this regard. In addition, it should be remembered that the carbon stock can only be preserved when innovative practices are continued for many years, therefore the sustainability of projects is crucial to achieve durable climate benefits.

At the **policy level**, most of the projects tackled the 2006 version of the EU soil strategy, but the projects' contributions are still valid as the soil issues targeted are the same in the 2022 version. In particular, some of the proposed solutions can be related to the specific objectives identified in the new EU strategy within the sectors of mitigation and adaptation, circular economy, biodiversity, sustainable management and water resources. Aside from a very few exceptions, the beneficiaries and stakeholders interviewed during the ex-post visits highlighted the necessity of a European directive devoted to soil protection, as this is considered essential to push the Member States to enforce similar policies, to guarantee durable and widespread actions devoted to soil themes that are often disregarded at local level. In addition, the updating of local regulations on urban planning is deemed necessary in order to facilitate the adoption of an innovative approach that takes the ecosystem services provided by soils into due consideration and thus reduces the land uptake at municipal level.

Even though half of the projects could be considered as policy innovative at the time of their implementation, only a quarter contributed concretely to the design of new legislation at local level or are directly connected to existing regulations. Some recommendations and feedback on possible legislative bottlenecks have also been collected, highlighting different points of view of actors and stakeholders from multiple productive sectors.

In addition, two beneficiaries submitted written contributions during the consultation phase of the forthcoming EU Soil Health Law, providing recommendations and raising concerns.

On the **economic** side, the vast diversity of the projects and sectors involved in the study did not allow generic considerations to be pointed out. In any case, the beneficiaries and stakeholders provided interesting information related to market prices of products or innovative systems, costs for remediation activities and the proper management of rural areas, as well as the financial implications caused by land take. All quantitative and qualitative assessments collected in the ex-post visits are reported in Table 7 (Section 6.4).

The ex-post exercise showed that no projects generated additional revenues and jobs through project activities, but, in some cases, the success achieved acted as a driver for economic benefits at local level, especially in the agricultural sector. However, detailed cost-benefit analyses that take into account all the elements involved in the production chain as well as the environmental aspects are not available, but are advisable as this is the most useful information to support decision makers at various levels on the adoption of environmental actions and the design of policies.

The study confirms that the approach followed from LIFE14 onwards, for a more structured and result-oriented monitoring of project impacts and achievements, should lay the groundwork for a more streamlined assessment of project results in ex-post studies to be carried out in the future. Yet, some soil-related **recommendations for the LIFE programme** can be highlighted.

The number of LIFE projects specifically devoted to soil themes (concluded as well as ongoing) is quite low (less than 50 projects since 2007), if we consider the wide range of environmental issues to be tackled, and thus it is difficult to carry out general assessments due to the lack of common objectives or targets among the projects. The sectors with a higher number of soil-related projects are the agricultural and remediation ones, that is, the sectors directly linked to productive activities, while projects in the land management sector, dealing with more extensive soil issues – e.g. erosion, desertification, hydrogeological issues and soil sealing – are limited to very few examples.

In addition, the projects are not homogeneously distributed geographically. Italy and Spain are the countries with the higher number of soil-related projects, and beneficiaries of the Mediterranean area seem more interested in tackling soil issues, even in projects not specifically devoted to soil. It is therefore desirable to have more LIFE projects located in central and northern Europe to address specific soil themes (e.g. management of organic soils, acidification, loss of fertility, etc.) and facilitate the circulation of new ideas through networking.

Lastly, more efforts should be made to **raise the awareness** of both technicians/professionals and citizens on soil issues. Actually, soil is a sort of 'invisible' element of the landscape and the environment and often not adequately covered in the activities developed by LIFE projects dealing with other environmental aspects of the relevant territories. In addition, it is necessary to increase the awareness of citizens on the importance of soil for the quality of their lives, to push for more durable efforts from policy stakeholders in supporting soil-related interventions and multiply the results achieved at local level.

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