# NOVASOIL

INNOVATIVE BUSINESS MODELS FOR SOIL HEALTH

Grant agreement ID: 101091268

# PIL CiRAA (Italy)



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## Project Consortium

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| 2 | LEIBNIZ-ZENTRUM FUER AGRARLANDSCHAFTSFORSCHUNG | GE |
| 3 | ZEMNIEKU SAEIMA | LV |
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# 1 Background, focal question and needs

This case study (CS) aims to analyse the environmental, social and financial benefits of long-term no-tillage and conservation agriculture (reduced tillage x cover crops) in IPM-based agriculture or the conversion to organic farming in arable cropping systems.
It focuses on **profiting from a long-term series of data** on soil fertility, crop yield, agri-environmental aspects and production costs, collected in controlled, experimental conditions (on-station) to support the transition towards more sustainable farming systems at the farm level.
It investigates the possibility of **developing business models** pivoting on soil fertility conservation (SOM increase) and the impact on other ecosystem services (e.g., sustaining farm biodiversity and resilience, reducing water use for irrigation and reliance on external inputs). The case study does not directly entail the dimension of the value chain.
The CS focuses on long-term experiments (LTEs) carried out on large plots/at field scales at the Centre for Agri-environmental Research "Enrico Avanzi" of the University of Pisa. Two field experiments focus on applying conservation agriculture techniques (i.e., reduced or no tillage, cover crops), whereas the third deals with organic vs conventional farming systems. The oldest field experiment started in 1986 and compare on around 2 ha continuous no-till vs annual mould board ploughing 30 cm depth on durum wheat and pigeon bean crops. Effects on soil fertility (SOC, C stock, bulk density, total N, available P, pH) are regularly assessed at different depths (0-10, 10-30, 30-60 cm), besides with crop yield and nutrient uptake. The second LTE is comparing on 4 ha since 1993 the combination of 2 tillage levels (reduced tillage vs annual ploughing 30 cm depth), 4 N fertilisation levels and four cover crop species (control, hairy vetch, radish, a mixture of the two) on a 4-yr arable crop rotation including durum wheat, sunflower and grain sorghum. Soil fertility issues, crop yield, weed abundance and composition are regularly assessed. In the third LTE, being carried out on 23 ha since 2001, an organic and a conventional management system are being compared on a 4-yr (conventional system: durum wheat-chickpea-common wheat and grain sorghum) or 8-yr (organic system: ordinary wheat-grain millet-grain sorghum chickpea- hemmer wheat-alfalfa) arable crop rotation. Thanks to the standard field plot size, soil fertility, crop yield and rheological quality, weed abundance and composition, energy use efficiency, and economic balance are regularly assessed.
The significant **environmental challenges** the CS addresses are loss of soil organic matter (SOM), GHG emissions, and water/soil/air pollution. All three long-term experiments in the CS target increasing SOM and reducing reliance on tillage and external inputs (mineral fertilisers, pesticides). Increasing soil organic matter means increasing soil water retention and infiltration (reducing drought and flooding risks), improving nutrient cycling and boosting biological processes (detoxification included). Reducing the intensity of soil management (tillage) and the reliance on environmentally hazardous agrochemicals can also reduce direct and indirect GHG emissions and water/air/soil pollution.
The main **barriers** are inadequate investment (funds, equipment, manpower) for implementing and maintaining large-scale, long-term experiments. Another barrier is the underdeveloped collaboration and knowledge exchange between researchers, farmers and other stakeholders to ensure the



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practical applicability of the study results. Furthermore, to ensure the effectiveness of the studies, access to a large amount of data and reliable analytical methods is necessary to assess soil fertility, crop yield, weed abundance, and other relevant parameters. The results of the experiments will have to consider regional or site-specific factors that may influence them, such as climate and soil type.
The CS **contribution** is a better understanding of the socio-economic implications of adopting different agricultural practices. This could include profitability, resource efficiency, and market demand for organic products. Moreover, the large amount of data in the case study could help identify effective indicators for measuring soil health, which policymakers could use.

# 2 Policy mix

Table 1 Key elements of national **policy mix and institutional framework around soils,** based on and adapted from Rogge and Reichardt, 2016; Williamson, 2000.

| **Domains** | **Elements to consider** | **Description** | **Lickert (1-5)** | |
|---|---|---|---|---|
| | | | **P**[1] | **Q**[2] |
| **0.Awareness and understanding** | Definition of soil health | The responses regarding the definition of soil health show a relatively clear understanding of the concept. According to the respondents (regional officials, agronomists, consultants, researchers and agricultural policy experts), soil health is associated with characteristics such as fertility, richness in organic matter and biodiversity, the ability to cultivate without relying on external inputs such as pesticides and fertilisers, and the ability to absorb and retain water. | 4 | 2 |
| **1.Policy concern** | Soils as policy priority | At the European level, soil is perceived by stakeholders as a very recent political priority. In fact, until the past CAP programming period, the environmental aspect was not as strong as in the current one, which has several measures with an impact on soil health. | 4 | 2 |

[1] P=priority. Please rank accordingly to 5 point-Likert scale based on how these elements are currently considered in your case study: 1 no priority; 2 low priority; 3 neutral; 4 moderate priority 5 high priority
[2] Q=quality. Please rank accordingly to 5 point-Likert scale based on the current quality of the political process in your case study: 1 very poor -2 poor; 3 acceptable; 4 good 5 very good


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| | | In Italy, it seems to be a secondary problem that is part of some broader policies, such as environmental and agricultural policies. It is therefore addressed by several policies. The different stakeholders and policy makers interviewed belonged to very different sectors and reflect the diversity of policies impacting on soil. One problem emphasised by many was the difficulty in obtaining a comprehensive overview of soil policies. | | |
| **2.Policy agenda on soils** | Political commitment towards soil health, non-binding targets | The main non-binding policies aimed at soil health at the moment seem to be those related to the CAP. In addition to specific measures to encourage good agricultural practices, eco-schemes represent a new element in this programming as they have a more or less direct effect on soil health. | 4 | 3 |
| **3.Institutional environment** | Binding national regulations on soil | The main binding soil-related policies are related to the environmental sector, e.g. water management policies that set limits on pollution and land use. There are also policies for the protection of specific natural areas. | 4 | 1 |
| **4.Policy integration** | Interactions between and within policy sectors | At the European level, policies are coordinated, an example being the green architecture of the CAP which includes aspects relevant to soil.<br><br>In Italy policies for the distribution of activities on the territory and land occupation should be coordinated with agricultural and environmental policies, which is currently not happening or is not happening effectively.<br><br>The problem of building occupation of land has emerged, in some cases unjustified, in the face of unused or unrenovated buildings. Our country has a high density of roads and buildings compared to other European countries, and this trend persists despite the obvious criticalities.<br><br>However, a greater degree of coordination between agricultural policies and those of inland areas in terms of land and soil management has been noted in this CAP programming. The care of the land in inland areas is a fundamental topic, | 5 | 3 |


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| | | because they are very fragile, mountainous areas, where the risk of floods and fires is very high. Therefore, soil care also becomes a fundamental element for prevention. | | |
| **5.Governance structures** | Levels of governance involved, roles and functions | This is related to the many policies that have an impact on soil management. Depending on the policies, the level of governance and its functions change.<br><br>The Italian regions have more power over agricultural policies, although from the point of view of the Italian CAP there has been a centralization with the current programming. In general, regions can also play a role in land management together with municipalities in terms of urban planning and thus land occupation. A major limitation is represented by the economic resources that can prevent concrete intervention by regions and local authorities, especially when it comes to land recovery. | 4 | 3 |
| **6.Contracts** | Property rights enforcement, land tenure agreements | The aspects that may affect the soil in the contracts are related to any certifications of the agriculture practiced and land falling within areas linked to European and Italian designation marks (PDO, PGI, TSG). On average, these aspects are reflected in better soil management. There are also some supply chain contracts that provide for specific cultivation standards that are reflected in the health of the soil.<br><br>In the field of medicinal plants, there are production standards imposed by international customers. These standards consider several aspects, including respect for soil fertility.<br><br>Some are pushing for the adoption of sustainable techniques such as regenerative agriculture. Some brands are already promoting to end consumers. products from regenerative agriculture.<br><br>Other aspects that influence the purchase and sale of land in Italy is its proximity to cities, such as areas of urban expansion. Or the possibility of installing photovoltaic panels. | 4 | 2 |



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| **7.Validation and coherence** | Mechanisms in place to measure impacts and ensure compliance to targets and limits | There are environmental indicators within the CAP that relate to soil, namely: soil organic matter and soil erosion by water. These two indicators are binding for the monitoring of the CAP.<br><br>Monitoring is generally difficult and costly and there are currently no indicators that evaluate the application of less intensive tillage on the soil. | 5 | 2 |
| **8.Non-governmental actors** | Role of different actors and multi-stakeholder coordination | Farmers play a key role as they are directly linked to the soil. Universities also play an important role in innovation and the dissemination of knowledge with various projects on environmental issues carried out with private stakeholders.<br><br>Farmers' trade associations also play the role of guiding farmers in new regulations and any new soil incentives.<br><br>Farmers' access to technical advice for the application of the best techniques for their soils is also crucial.<br><br>Then we have contractors who provide services and work on other farms, their role is fundamental as the services (like the tillage) they apply can have effects on multiple farms.<br><br>Manufacturers of agricultural vehicles and in particular ploughs are involved because of the development of more soil-friendly machines. Among the machines to be paid the most attention to are certainly ploughs (often used at too great depths with subsequent damage to soil fertility).<br><br>Producers of inputs (fertilisers and pesticides) are also involved in soil management in a more or less direct way. Inputs are now fundamental for intensive agriculture and a regulatory change on these can have enormous impacts. | 4 | 3 |
| **9.Allocation of resources and sources of finance** | Available budget for soil health and blended finance | No precise data was provided by respondents. However, the main funds allocated to soil health at the moment seem to be those linked to the CAP. In particular, eco-schemes represent a new element in this programming, in a more or | 3 | 3 |


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| | | less direct way they also have an effect on soil health.<br><br>Respondents do not know of any other funds. | | |
| **10.Policy consistency with soil health** | Synergies and trade-offs between policy sectors and towards soil ES | In the policies mentioned by the respondents, soil is seen as a supplier of food and biomass (mainly agricultural policies). The environmental aspect is also particularly strong, which is very much felt in Italy (a country characterized by a fragile territory at hydrogeological risk). | 4 | 2 |
| **11.Contextual factors** | Enabling and disabling conditions | The diversified economic interests of the different actors involved in soil management are a major issue that seems to limit soil policies. In particular, the fragmentation of these policies is perceived as a limitation of these policies.<br><br>One example is the lack of effective planning in land occupation, which leads to excessive land consumption. On the other hand, one aspect that can favor stronger policies is the obvious environmental problems due to the loss of soil health and the growing awareness of institutions. | 5 | 2 |

# 3 Policy directionality

*Aim of this section is to assess how existing instruments (regulatory and economic) put in place by the national policy mix are able to support business models for soil health. Policy instruments constitute the concrete tools to achieve overarching objectives and are usually associated with specific goals, i.e. the intended effect of instruments on the medium-long term. Furthermore, policy narrative are defined as the key words and concepts that express the political understanding of a problem, i.e. soil health.*

## 3.1 Instruments

Table 3 Assessment of **policy instruments** (adapted from Rogge and Reichardt, 2016)

| **PRIMARY TYPE** | **PURPOSE TYPE** | | |
|---|---|---|---|
| | **Supply** | **Demand pull** | **Systemic** |



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| Economic instruments | RD&D* grants and loans, tax incentives, state equity assistance | Subsidies, feed-in tariffs, trading systems, taxes, levies, deposit-refund-systems, public procurement, export credit guarantees | Tax and subsidy reforms, infrastructure provision, cooperative RD&D grants |
| Regulations | Patent law, property rights; land tenure; | Technology/performance labels and standards, prohibition of products/practices, application constraints; public procurement | Market design, grid access guarantee, priority feed-in, environmental liability law Information |
| Information | Professional training and qualification, entrepreneurship training, vocational training, advisory | labelling programs, public information campaigns; consumers organizations | Education system, thematic meetings, public debates, cooperative programs, clusters |

| **PRIMARY TYPE** | **PURPOSE TYPE** | | |
|---|---|---|---|
| | **Supply** | **Demand pull** | **Systemic** |
| **Economic instruments** | Direct payments for the introduction and maintenance of organic farm management and sustainable agricultural practices such as minimum tillage and the use of cover crops. | High European standards for organic certification that link the purchased product to a higher added value, also related to the protection of soil health. | CAP incentives for good agricultural practices and organic productions |
| **Regulations** | Non-binding but restrictive regulations on soil-impacting practices that are not allowed if one wants to access the | For organic farming, prohibition of products not allowed by the regulations.<br><br>Reduced tillage techniques (no use | European Commission's action plan for the development of organic production. |



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| | economic incentive. The incentives considered also take into account territorial diversity with rankings that consider the most suitable territories for the application of the practices or the most fragile (as in the Tuscan application of the CAP). | of sludge, no ploughing).<br><br>For cover crops no use of herbicides and fertilisers.<br><br>Ban on the use of glyphosate in all cases in Tuscany. | The overall objective of the plan is to stimulate the production and consumption of organic products, so that by 2030 25 % of agricultural land will be used for organic farming.<br><br>This opportunity for system change can be used to encourage the adoption of more sustainable soil management techniques permitted in organic farming. |
| **Information** | Education concerning organic farming techniques and sustainable farming practices (e.g., those promoting biodiversity and water storage functions of soil); farming workshops and events with the purpose of information dissemination | Public information campaigns and labelling programs mainly related to organic farming. | Initiatives to disseminate information on organic products among citizens through schools, universities, fairs and information material. |
| **Description*** | **1) Payment to adopt and maintain organic farming practices and methods**<br>The target of this instrument are farmers. It serves to implement several EU objectives: mitigating climate change by reducing greenhouse gas emissions and improving carbon sequestration, developing sustainable management of natural resources by reducing | | |


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| | dependence on chemicals, stopping biodiversity loss, improving ecosystem services and preserving habitats and landscapes, producing healthy and nutritious food sustainably, reducing food waste, improving animal welfare and combating antimicrobial resistance.<br><br>It is based on the obligation of means (organic farm management). In the event of non-compliance with the provisions of the incentive, the financial contribution is lost. This instrument directly impacts soil health.<br><br>**2) SRA29 Reduced tillage techniques**<br>The target of this instrument are farmers. It serves to implement several EU objectives: mitigating climate change by reducing greenhouse gas emissions and improving carbon sequestration, promoting sustainable development and efficient management of natural resources such as water, soil and air, including by reducing chemical dependency.<br><br>It is based on the obligation of means. In the event of non-compliance with the provisions of the incentive, the financial contribution is lost. This instrument directly impacts soil health.<br><br>**3) SRA03-ACA3 Cover crops**<br>The target of this instrument are farmers. It serves to implement several EU objectives: mitigating climate change by reducing greenhouse gas emissions and improving carbon sequestration, promoting sustainable development and efficient management of natural resources such as water, soil and air, including by reducing chemical dependency.<br><br>It is based on the obligation of results. In the event of non-compliance with the provisions of the incentive, the financial contribution is lost. This instrument directly impacts soil health. |

## 3.2 Policy narrative

Table 3 Description of the policy narrative (based on Lehmann et al, 2020)


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| **Policy narrative (and scale of action)** | The CS investigates the possibility of **developing business models** pivoting on soil fertility conservation (SOM increase) and the impact on other ecosystem services (e.g., sustaining farm biodiversity and resilience, reducing water use for irrigation and reliance on external inputs).<br>The case study does not directly entail the dimension of the value chain. It focuses on long-term experiments (LTEs) on large plots/field scales at the Centre for Agri-environmental Research "Enrico Avanzi" of the University of Pisa. Two field experiments focus on applying conservation agriculture techniques (i.e., reduced or no tillage, cover crops), whereas the third deals with organic vs conventional farming systems.<br>Therefore, it operates on all scales: globally, it aspires to contribute to innovative soil management techniques and climate change-resistant crops. Nationally and regionally, it introduces new ways to manage the soil and fields. Locally, it provides products to researchers and the local community. The involved stakeholders are transnational and national and regional policymakers, alongside international and national researchers, farmers and local communities. The CS addresses all three soil narratives: soil fertility (by introducing new organic farming possibilities such as bio-herbicides and cover crops, soil health (by introducing no-tillage soil management techniques and soil security by adopting soil conservation practices and promoting its climate change impacts resistance. |
| **Policies and incentives in place** | • Payment to adopt and maintain organic farming practices and methods;<br>• SRA29 Reduced tillage technique;<br>• SRA03-ACA3 Cover crops. |
| **Land tenure and contracts** | The CS focuses on long-term experiments (LTEs) on large plots/field scales. The fields are the property of the University of Pisa (Centre for Agri-environmental Research "Enrico Avanzi). |
| **Manageme nt strategies applied** | • Implementing conservation agriculture techniques such as reduced or no tillage and cover crops to improve soil fertility and reduce soil erosion.<br>• Implementing organic farming to improve soil fertility (above all organic matter content and biological activity), reduce pollution risks linked to agrochemical use and preserve biodiversity.<br>• Long-term experiments (LTE) and large-scale research on organic and conservative agriculture Farmers' access to data. |
| **Soil functions interested** | Fertility, water and nutrition storage and reservoir, biodiversity promotion, carbon storage reservoir. |


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| **Ecosystem services addressed** | • Water storage, filtration and nutrient cycling<br>• Promotion of biodiversity<br>• Carbon reservoir (C sink)<br>• Landscape complexity<br>• Food supply and biomass production<br>• Physical platform and cultural services for people |

# 4 Mapping exercise

## 4.1 Synthesis of the value mapping

*Aim of the value mapping is to understand level of awareness of and purpose towards soil health as framed by the business model (Barth et al, 2015).*

*Looking at the business model, please describe the following elements:*

a. Value proposition

- **What are the causes of degradation?**

The causes of soil degradation are intensive agricultural practices in association with the impacts of climate change.

- **What are the socio-technical solutions proposed (BM)?**

1) Implementing conservation agriculture techniques such as reduced or no tillage and cover crops to improve soil fertility and reduce soil erosion.
2) Implementing organic farming to improve soil fertility (above all organic matter content and biological activity), reduce pollution risks linked to agrochemical use and preserve biodiversity.
3) Long-term experiments (LTE) and large-scale research on organic and conservative agriculture Farmers' access to data.

- **Why do soils matter in the BM?**

The soil matters in this BM since it is a crucial element of crops growing. For CiRAA, it is essential to continue new experimental farming techniques and other long-term experiments to improve the quality of crops and invent and test new farming strategies and new crop variants and species to enhance their resistance.

b. Value creation and delivery

- **What soil ES are targeted by the business model? (list based on soil strategy)**

- Water storage, filtration and nutrient cycling,



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- Promotion of biodiversity,
- Carbon reservoir (C sink),
- Landscape complexity,
- Food supply and biomass production,
- Physical platform and cultural services for people.

- **What soil ES are not provided / neglected**?

- Source of raw materials,
- Geological, geomorphological and archaeological heritage archive.

- **Public/private - who can benefit from that values?**

Both public and private benefit from the values provided by BM. Most of the delivered (or intended to be delivered) ES are of public interest but can create market opportunities also for private companies and actors either in upstream (e.g. builders of machinery for reduced tillage, seed companies selling certified organic seeds or cover crop seeds) or downstream (e..g. food processors, local shops, environmental tourist guides).

- **What trade-offs emerge? Are the causes addressed?**

On the downside, the move to organic system could be costly and lead to some economic pressure on the farm. On this line, the problem of a possible drop in production is economically relevant. Furthermore, the increase in biodiversity, although an element that guarantees greater resilience of the system, could also be negative (in the case of negative biodiversity for production, e.g., weeds, pests and pathogens). In general, the increased complexity of field management could be a risk for the farmer, as it implies costs for gaining knowledge, additional working time for field operations and possible conflicts with other farm operations. This might induce farmers to intensify crop management to simplify management, on the one hand, and to increase yields, on the other hand, but then loosing environmental benefits linked to organic farming.

The possible benefits are reflected in the increased value of the product and the supply chains. Organic farm management, especially, creates new development and market opportunities for farmers and value chain actors. Companies that produce agricultural machinery designed, for example, for minimum tillage or more suited to the organic system in general, can profit from a high number of farmers converting to organic farming. The same is true for producers of products allowed for use in organic farming, such as organic fertilizers and biopesticides, encouraging innovation and economic growth in these sectors. Furthermore, there might be opportunity to set collective strategies to boost the economy at land level, e.g. by establishing bio-districts.

c. Value capture

- **What soil ES are targeted by the incentives?**

- **Incentive 1**. Payment in order to adopt and maintain organic production practices and methods:
  1. Water storage, filtration and nutrient cycling
  2. Promotion of biodiversity
  3. Carbon reservoir


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4. Food supply and biomass production
5. Physical platform and cultural services for people
6. Source of raw materials

- **Incentive 2**. SRA29 Reduced tillage technique:
  1. Water storage, filtration and nutrient cycling
  2. Promotion of biodiversity
  3. Carbon reservoir
  4. Food supply and biomass production

- **Incentive 3**. SRA03-ACA3 Cover crops:
  1. Water storage, filtration and nutrient cycling
  2. Promotion of biodiversity
  3. Carbon reservoir
  4. Food supply and biomass production

- How is value distributed along the stakeholders?

- Water storage, filtration and nutrient cycling: reflected on by farmers;
- Promotion of biodiversity: reflected on by farmers and researchers
- Carbon storage and physical platform and cultural services for people: reflected on by farmers and policy makers

- Where do the resources come from (public/private)?

Concerning public resources, the research centre utilises various European, national and regional funds. Such as grants from programs like Horizon Europe, and research projects aimed at promoting sustainable agricultural practices and soil conservation. There are also several collaborations with public universities and research institutes that provide additional funding, expertise and resources.
As for private resources there are also several partnerships with private non-profit associations dedicated to environmental conservation and sustainable agriculture. These organizations contribute through funding, joint projects, and knowledge sharing.
Finally, we have partnerships with seed companies that provide seeds for testing and expertise for the development of crop varieties suitable for organic farming. Similarly, agricultural machinery manufacturers provide equipment and technical assistance to test and improve sustainable agricultural technologies.

- How is soil health described and framed by the business model? (place in the picture)
  - BM: Long-term experiments (LTE) and large-scale research on organic and conservation agriculture
  - Essential soil ES within this BM are water storage, filtration, nutrient cycling, biodiversity promotion, and raw material sources. If soil disposes of these, it is considered healthy.
  - Also, this is linked to the local level with the distribution of food and crops among locals and researchers related to CiRAA, potentially impacting regional, national, and global levels since their experiments can bring novelty to the crop harvesting patterns worldwide.


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## 4.2 Solution mapping synthesis

a. What innovations and changes are we looking for?

- There is a strong need to adopt the usage of bioherbicides and new forms of herbicides to abandon, e.g., glyphosate usage, which is unsafe for humans and animals. Alternatives to herbicides are considered essential for the implementation of both organic farming and conservation agriculture techniques. Weeds are indeed one of the biggest technical barriers for the adoption of organic farming and conservation agriculture.

b. What regulatory and policy conditions would we need?

  - Regarding policy conditions, the bureaucracy in Italy needs to be simplified in the short term. The current bureaucracy is so complicated that farmers often do not apply for funding because they want to avoid the process.
  - The question arises concerning whether to regulate carbon stocking. The time horizon for this is vast because the evaluation of the efficiency of carbon stocking requires longitudinal research (up to 20 years). With the short-term propositions, there is a problem that it is hard to say whether or not it works. This should be taken into account (policies need to consider this).

- What regulations (binding or not) and resources (new incentives) are needed?

With the next CAP, we need more systemic incentives because it is concrete when a single practice is applied. An incentive that would target things more broadly is required.

- Are there some contradictions between tools and/or policies?

The problem with the current incentives system is that they sometimes support techniques and practices that would not be otherwise implemented (e.g., the regional schemes for cover crops oblige farmers to keep the cover crops on the field not later than April, but actually this could be contrasting in years when the cover crops are sown late due to harsh weather in the fall, i.e., before April their biomass and related ES could be very low).

Systemic incentives for farmers and integration of these incentives with other measures, considering more environmental policies interconnected with agriculture, are needed. This is also needed when designing and implementing region-specific incentives, not in terms of administration but in a geographic area: this would bind new areas based on the characteristics of the regions.

- What could be the effect of the soil monitoring law?


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We think this could be negative for this BM because it brings very general rules and incentives for cases that might be very specific. Also, since CiRAA is an experimental site, it has special requirements for soil management; it is a question if the soil monitoring law takes this into account.

- What contractual solutions and terms and what kind of guarantees are needed for business model implementation? (e.g. certification)

It is essential to establish supply chain contracts and cooperatives involving all actors in the agricultural supply chain. The adoption of sustainable practices throughout the production process must be guaranteed by certifications. These contracts must include specific terms relating to sustainable agricultural practices, use of innovative technologies and compliance with environmental standards.

Long-term supply agreements between farmers and buyers, such as supermarket chains or food companies, are crucial to provide stability and predictability. These agreements must include fair prices that reflect the additional costs of sustainable practices and commitments to purchase organic or certified products. An alternative to these contracts can be short supply chains to ensure a better relationship between farmer and consumer on the local area.

In addition, innovation partnerships between farmers, research institutions and technology providers are crucial. Financial guarantees are also needed to protect farmers from the economic risks associated with adopting sustainable practices. In addition, research funds and long-term trials are needed to provide solid data to farmers on various sustainable practices.

c. What resources could facilitate the change?

   - Implementing conservation agriculture techniques, such as reduced or no-tillage and cover crops, to improve soil fertility and reduce soil erosion.
   - Adequate resources for implementing and maintaining long-term experiments.
   - Access reliable data and analytical methods for assessing soil fertility, crop yield, and other relevant parameters.
   - Collaboration and knowledge exchange between researchers, farmers, and other stakeholders to ensure the practical applicability of the study findings. One example could be the establishment of living labs where experimental centres act as lighthouse, implementing long-term experiments (LTEs) without any risk for farmers, who can be part of the management board of the LTEs themselves.

## 4.3 Pathways mapping

- CHANGES: what is needed in terms of regulations and institutions; social habits; products and technologies, services and infrastructure?

- Regulations and Institutions: There is a need for robust regulations that balance energy production and agricultural productivity. Policies



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should incentivize the installation of solar panels on agricultural buildings rather than on arable land to prevent conflicts between energy and food production. Regulations should also support the principles of organic farming through systemic incentives that do not refer to individual practices. Institutions should also strengthen policies against soil sealing to protect agricultural land from conversion to non-agricultural uses.

- Social Habits: Changing social habits is crucial to support sustainable practices on organic farms. Raising awareness of the importance of preserving farmlands and the impacts of more sustainable farming practices on soil health is essential. Short supply chains seem to be the most effective way at the moment to recognise the value of sustainable agricultural practices.

- Products and Technologies: Advances in products and technology are critical for arable farms that practice organic and minimum tillage. Organic farming requires innovative techniques such as crop rotation, cover crops and intercropping to improve soil health and biodiversity. Continued development of machinery is also essential. Finally, the search for natural substances and techniques to protect crops from abiotic and biotic problems is essential.

- TRENDS/DRIVERS: what is the influence of the social, economical and environmental context?

- Competition between countries inside and outside the EU is a significant factor. One example of this problem is the EU's trade agreements with countries that offer agricultural products at low prices. These agreements can lead to economic advantages, but also to unfavorable competition for Italian producers. This dynamic can negatively affect sustainable Italian production and lead to unfair competition. This driver can have a significant impact on agricultural and trade policies, prompting a review of strategies to primarily protect local producers who apply sustainable agricultural practices.

- ACTIVITIES/RESOURCES: what skills, knowledge, partners are needed?

- To increase cooperation among farmers (new practices and experience, new ways to use new practices), cooperation must involve partners who can organize events demonstrating the latest innovations, research results, etc. These events are a platform for collaboration among partners and give them the knowledge—dissemination of practices and new ways to manage.
- Data from long-term experiments (longitudinal data) are required for policies so they can determine whether this practice is good or bad for the environment. After 30 years, the soil is good or better in the long term. These data must be supported because they cannot


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be related to projects. After all, projects are dying too fast. This could provide data for the platforms for farmers we talked about before.

Table 4 Pathways mapping

| | **Short term**<br><br>**(up to 3 years)** | **Medium**<br><br>**(3 - 7 years)** | **Long term**<br><br>**(after 7 years)** |
|---|---|---|---|
| **INNOVATIONS** | | | |
| **Regulations and binding policies** | Simplification of Italian bureaucracy. | Need for more systemic policies: something that can link policies that have an impact on the soil more closely with agricultural policies | We need long-term (20-year) research on carbon stocking, so we need policies that understand that soil needs lots of time. |
| **Incentive instruments** | n.a. | Need for more systemic incentives | Long-term incentives for sustainable agricultural practices and soil management. |
| **Contractual solutions** | Fair long-term supply agreements between farmers and buyers | Innovation partnerships between farmers, research institutions and technology providers. | Contracts that support sustainable practices and protect farmers' interests in the long term. Certifications to ensure sustainable agricultural practices. |
| **Infrastructure** | Development of platforms for the dissemination of agricultural knowledge. | Investment in lighthouses to support agricultural research, innovation and dissemination. | Advanced infrastructure to monitor and improve soil health. |
| **Product** | n.a. | Development of new crop varieties suitable for | n.a. |


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| | | | |
|---|---|---|---|
| | | organic and sustainable agriculture. | |
| **Services** | Advisory services for the adoption of sustainable practices. | n.a. | Integrated services for sustainable farm management. |
| **Technology** | New substances and technologies to be used in organic farming | Advanced technologies for soil monitoring and management. | n.a. |
| **Institutions** | n.a. | Strengthening institutions that support agricultural research and the dissemination of sustainable practices. | n.a. |
| **Actors' configuration** | n.a. | Development of collaboration networks between actors in the agricultural supply chain. | n.a. |
| **Coordination mechanisms and partnerships** | Platforms for farmers to learn and disseminate knowledge. | Public-private partnerships to support research and innovation. | n.a. |
| **RESOURCES** | | | |
| **skills, knowledge, R&D** | Skills and knowledge to increase cooperation between farmers. Implementation of conservation farming techniques such as minimum or no tillage and cover crops. | Data from long-term experiments to support agricultural policies. Adequate resources to maintain long-term experiments. Access to reliable data. | Continuous resources for long-term research and development. Collaboration and knowledge exchange between researchers, farmers and other stakeholders, e.g. through living labs. |


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| | | | |
|---|---|---|---|
| **DRIVERS: social habits, economic, environmental** | Impacts of trade policies on sustainable agriculture. Competition between countries inside and outside the EU and protection of local producers. | Change in social habits. Awareness of the importance of preserving farmland and the impacts of sustainable agricultural practices on soil health. | Adapting to the dynamics of global competition and protecting local producers. |

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