NOVASOIL

INNOVATIVE BUSINESS MODELS FOR SOIL HEALTH

Grant agreement ID: 101091268

CO2 Land

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Project Consortium

N°	Participant organisation name	Country
1	EVENOR TECH SLU	ES
2	LEIBNIZ-ZENTRUM FUER AGRARLANDSCHAFTSFORSCHUNG	GE
3	ZEMNIEKU SAEIMA	LV
4	NEW BULGARIAN UNIVERSITY	BU
5	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	FR
6	KOBENHAVNS UNIVERSITET	DK
7	TECHNISCHE UNIVERSITAET MUENCHEN	GE
8	ASSEMBLEE DES REGIONS EUROPEENNES FRUITIERES LEGUMIERES ET HORTICOLES	FR
9	ISTITUTO DELTA ECOLOGIA APPLICATA SRL	IT
10	UNIVERSITA DEGLI STUDI DI FERRARA	IT
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14	UNIVERSITA DI PISA	IT
15	ASOCIACION AGRARIA JOVENES AGRICULTORES DE SEVILLA	ES
16	UNIVERSITY OF LEEDS	GB

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1 Background, focal question and needs

The CO2-Land initiative aims to make a significant contribution to climate protection by using scientifically proven methods to create CO2 sinks in arable soils and make soils more resilient with regard to climate change and their ecological functions. In order to achieve these goals, it networks with actors from politics and industry to provide information about these potentials and to win customers for the purchase of climate certificates. These are offset by farmers who, in return, commit to continuously increasing the organic carbon content of their soils. With the proceeds from the sale of the certificates, the farmers are then (partially) compensated for their additional efforts.
The case study aims to identify the success factors of the initiative in order to implement similar models across Europe and to ensure farmers' long-term commitment and social acceptance of carbon certificates. This includes the creation of a network with similar projects to exchange knowledge and generate ways for funding, especially in the initial phase. Strategies will also be collected to expand the initiative to new soil health products. At the same time, the acceptance of this concept among different stakeholders such as the farmer, society or potential buyers will be determined.

The initiative focuses on increasing the SOC content of soils, trying to reverse a long-lasting trend of intensification in agriculture. Until now, the trend in agriculture has been toward intensification. Narrow crop rotations with a high proportion of humus-consuming crops has led to a steady reduction in the SOC content of agricultural
soils in many areas. Soil life and humus content is also impacted by intensive tillage such as ploughing of the soil in order to suppress pests and weeds. Also, climatic changes lead to increase in the frequency of extreme weather events such as heavy rainfall which can additionally lead to a reduction in SOC content (for example, the removal of the humus layer of the soil by erosion caused by heavy rainfall or storms).
To maintain healthy and resilient soils, the SOC content must be increased. Challenges are extreme weather events like heavy rain or storms leading to erosion but also heat and drought events. In addition, climate change is altering disease or weed pressure, which may make it more difficult for farmers to establish soil conservation measures such as no-till practices.
Soil health is a critical factor in food production. The demand for food is increasing. If production is hampered by climate change and decline in soil health, production costs and risks might increase, which in turn can increase costs for consumers. In addition, a healthy, resilient agricultural ecosystem leads to a better quality of life in the countryside.
Agriculture has a very special role to play in the fight against climate change. Unlike many other sectors, it has the potential to remove CO2 from the atmosphere during production by carbon sequestration. To do this, the SOC content in soils must be increased. Unlike other carbon mitigation schemes, which often only cover single plots, CO2-Lands approach is to include the entire farm in the carbon sequestration
evaluation. The humus build-up is stimulated, e.g., by optimizing the farm's crop rotation or other techniques agreed upon jointly with the farmer. The farmer can then be compensated for the resulting additional costs (e.g., due

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to additional machinery cost, wider crop rotation and less profitable crops, seeds for intercropping, ...) through
the sale of CO2 certificates.
In order to be able to sell regional climate protection certificates, a sufficiently large number of farmers need to participate in the initiative. Another challenge is to find buyers for the certificates. To do this, the system needs to be publicized among farmers as well as potential buyers. The recognition of society also plays a role, for which credibility of the concept and ensuring long-term effects is crucial.

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	Soil health has not been a major issue in the national and local context in the past. But that's changing at the moment. Soil health is becoming a priority. One reason for this is certainly climate change, including the increasing number of extreme weather events. A healthy soil is a soil that can meet all ecosystem services and that is able to produce healthy food. Soil should have a buffer function against biotic and abiotic disturbances. From an agricultural point of view, maintaining productivity is crucial, defined by soil structure, root penetration, and plant growth. "A soil is healthy if it can fulfil its functions". Soil health is a major issue in the national context, especially in view of the new, upcoming law that is to be adopted at the EU level. The Soil monitoring law will soon be submitted to the Federal Council for a vote. Then, there would soon be EU rules on	4	/

[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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		how to define soil health. The law contains 11 indicators with specific limit values for soil parameters. The first suggestion for the law was: If even one of the 11 indicators is not met, the soil is considered unhealthy. But there was too much resistance, so it probably won't be so severe. Indicators are pollutants, soil compaction, biology, salinization, erosion, clay-humus ratio, etc. This will remain the dominant theme for the next few years. If the first step is monitoring, there must soon be a law on what happens if the soil is unhealthy. Very vague so far, by 2050, all soils in the EU must be in good condition. This has far-reaching consequences for farmers and authorities.		
1.Policy concern	Soils as policy priority	In the meantime, there are more and more initiatives and funding for soil health. For example, the ministry has launched the Climate Humus Network, in which humus-effective strategies are tested on 150 pilot farms. Another example is the "Network Crop Production" on the subject of humus build-up. So, there are now a number of initiatives that are financially supported at the political level. Practitioners, however, state that the commitment is still not enough. This can also be seen in the fact that environmental events such as heavy rainfall events repeatedly have serious effects on agricultural soils. More measures for soil health are needed here. Although there are measures, such as winter greening, these are only voluntary, rarely proactive offers. It would be proactive, for example, to support investment in new technology (e.g. strip-tillage). Commitment: A lot is driven by EU law (question 0). The state must turn this into a national law if this is approved. So, the state has to act. Since it has become clear that there should be a law, some associations have also been dealing with it. E.g. organic farming associations. Also, there are associations that are against the fact that there is even more bureaucracy. Examples of political measures in Bavaria are KULAP	2	3

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		measures (agri-environmental measures of the 2nd pillar of the CAP), which have been expanded to include soil health measures in the new funding period.		
2.Policy agenda on soils	Political commitment towards soil health, non-binding targets	All measures in the second pillar of the CAP are non-binding (not mandatory for the farmer). In the agri-environmental measures (state level), there are now several measures with the aim of improving soil health. These relate to soil-conserving cultivation methods or crop rotation and, thus, the cultivation of humus-increasing crops. Eco-schemes (EU level) of the first pillar are also voluntary, although they prioritise biodiversity rather than soil health. There are a large number of projects and associations that deal with the topic of soil. E.g., IG Healthy Soil, Down-to-Earth Project, and Bioland Foundation. These are not direct strategies but initiatives.	5	/
3.Institutional environment	Binding national regulations on soil	In order to receive direct payments, GAEC standards must be complied with. These include some standards that improve soil health. However, due to the 4% set-aside, more and more farmers are inclined to stop applying for direct payments. Otherwise, the Federal Soil Protection Act contains the requirement that the humus content in the soil should remain stable. However, this is not monitored. Although farmers have to send soil samples every 5 years, only the main nutrients are tested (Phosphorus, potassium, pH). Soil health is more likely to be monitored within the value chain/quality management (e.g. dairy, associations and certification), but not at the state level. There is a nationally binding policy that integrates soil protection. Key point EU Soil Strategy 2030.	3	2
4.Policy integration	Interactions between and	Conflict between the Ministry of Agriculture and the Ministry of the Environment over the question of whether glyphosate may still be used in the future.	2	2

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	within policy sectors	Another conflict is the regulation of 4% set-aside. The aim is to promote biodiversity. However, other measures would be more efficient for soil health. In the future, there will be an annual exchange between the Ministry of Agriculture and the Ministry of the Environment on the subject of soil protection. This is intended to be a cross-ministry institution interested in Bavaria soil health. The conflict of objectives is species protection vs. soil protection.		
5.Governance structures	Levels of governance involved, roles and functions	The levels of government involved are the EU, the state and the governments of the individual federal states in Germany. In addition, various agricultural offices within the federal states are responsible for farmers. For the farmers, i.e. practitioners, the responsible office is the most important level, as it is the direct contact point. However, there is still no contact point specifically for of soil health. Biodiversity advisors have been around for a few years, but nothing has yet been established focusing on soil health. Most of the departments' resources are used for inspections, not for advice or knowledge transfer. EU: Development of the Carbon removal certification framework. Germany: Not there yet, focus not so much on humus build-up, but thanks to the EU's initiative, Germany is slowly catching up. Ministries are involved, such as LFL (Landesanstalt für Landwirtschaft) as executing/advisory authorities and, at the regional level, the Offices of Food, Agriculture and Forestry, which provide direct support to farmers. Offices put projects of the ministry and the LfL into practice at the regional level.	/	/
6.Contracts	Property rights enforcement, land tenure agreements	Some municipalities specifically lease agricultural land they own only to organic farming institutions or only under conditions promoting biodiversity. In addition, private initiatives (e.g., A.ckerwert)	2	4

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		help landowners to include environmentally friendly strategies in lease agreements. So far, however, these are isolated cases. In general, only price and demand are decisive when it comes to farm land. Financial matters are still at the forefront of leasing. An important stakeholder here is the Church, which owns a lot of land.		
7.Validation and coherence	Mechanisms in place to measure impacts and ensure compliance to targets and limits	There are hardly any monitoring mechanisms for soil health. Cut-off dates (e.g., blocking periods for applying organic fertilisers) that may indirectly affect soil health are checked. Validation is not possible due to a lack of standards. To this end, the term soil health would have to be precisely defined and set as an objective. Soil monitoring is already in place in most German federal states to monitor soil conditions. The program has been around since the mid-80s. There are soil samples from practice areas of each soil type. The results are not passed on to farmers because they are not supposed to influence farming. A neutral, silent observation every 5 years to see how soils develop chemically, physically and biologically. LfL, LfU and LfF do this in close cooperation as forestry-, agriculture- and the environment-partner.	5	2
8.Non-governmental actors	Role of different actors and multi-stakeholder coordination	Private initiatives are CO2-Land, Bodenfruchtbarkeitsfonds, IG Gesunder Boden, Gesellschaft für konservierende Bodenbearbeitung, positerra. So far, there is no real coordinated cooperation. In the state of Schleswig-Holstein, there was an initiative to bring together various organizations that promote humus build-up. But that fell apart again after some time. The various organizations also have profit interests and see themselves as competitors because they are not purely driven by charitable motivations. Greenpeace, WWF, associations (organic farming associations), and farmers' associations.	4	2

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9.Allocation of resources and sources of finance	Available budget for soil health and blended finance	Private funding: see organisations in question 8. Subsidies: Project Klima-Humus. It is often difficult for farmers to find resources, although this varies from state to state. Here, again, the responsible Office for Agriculture is decisive. This is the basis for communication and information transfer. Part of the 2nd pillar of the CAP is used for soil measures. Private funds are rather scarce.	5	3
10.Policy consistency with soil health	Synergies and trade-offs between policy sectors and towards soil ES	Food: High priority, regionality is currently more important than soil health. Water/nutrient: Groundwater protection and organic fertilisation are closely related to soil health. Biodiversity: Following a referendum in 2019, biodiversity is highly prioritised. However, this affects more above-ground biomass, i.e. bees and flowering areas. Soil health is of secondary importance. Cultural services: High priority, e.g. promotion of the cultivation of alpine pastures, soil health plays a minor role. Sources of raw materials: Conflict with soil health, as soil is often mined here. Geological, archaeological heritage: No direct connection. The agri-environmental schemes are about ecosystem services (water uptake, nutrients, biodiversity, carbon storage). In the first pillar of the CAP with direct payments, food production is prioritised. With regard to soil health, there are no relevant measures for cultural services and raw material sources.	3	3
11.Contextual factors	Enabling and disabling conditions	- Lack of awareness and know-how among farmers about soil health. Many practices are used because they have been used for generations. - Funding instruments usually only have a supportive effect but do not fully	4	2

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		cover additional costs. Therefore, a high level of personal commitment from the farmer/farm is always necessary when switching to soil-friendly strategies. Participating in national programmes often incurs more costs than simply not participating. - It takes a long time for politics to make a difference, and agricultural practice has a low priority. Example: The ban on glyphosate has been discussed for several years and the decision has been postponed again and again. This creates uncertainty among farmers. Especially in soil-friendly practices such as ploughless cultivation, glyphosate can be an important emergency anchor. Politics is very erratic. One example is the 4% shutdown, which is now being suspended again. Humus build-up in particular is a long-term process. If subsidies and regulations are suddenly changed every few years, this is a major barrier for practice to do something long-term. Hindering: Most people are not yet aware of the importance of soil. There is already an understanding of biodiversity, but soil is very abstract and is not associated with emotions compared to extinct animal species, for example.		

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.

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3.1 Instruments

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

PRIMARY TYPE	PURPOSE TYPE		
	Supply	**Demand pull**	**Systemic**
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	Payments for ecosystem services. Direct payments require good agricultural and ecological status of land. Minimum soil coverage to avoid soils without vegetation during sensitive periods of the year is required to	Privately or state-financed funds with the aim of promoting soil health.	Ordinance on the use of fertilisers, soil additives, growing media and plant aids in accordance with the principles of good practice in fertilising2 (Fertiliser Ordinance - DüV) This ordinance regulates

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	receive direct payments.		1. good professional practice in the application of fertilisers, soil additives, growing media and plant aids on agricultural land, 2.the reduction of material risks through the application of fertilisers, soil additives, growing media and plant aids on agricultural land
Regulations	In the period from 15 November of the application year to 15 January of the following year, a minimum soil cover must be ensured on at least 80% of the farm's arable land (Winter crops, catch crops, stubble fallow, mulching tillage, green cover)	Example funds: The aim of IG gesunder Boden e. V. is to build healthy soils as a basis for healthy plants, animals and people. Through a supra-regional network of practitioners, an exchange of knowledge takes place with the aim of building healthy, living and humus-rich soils that produce high-quality plants and food. The HumusClimateNet is a model and demonstration project for building up humus in arable soils. Until the end of 2027, measures to build up and maintain humus as a contribution to climate protection will be trialled and rolled out on 150 farms across Germany - half organic and half conventional.	Obligation to keep records. Determination of fertiliser requirements. Fertilisers containing nitrogen or phosphate, soil additives, growing media and plant aids may not be applied if the soil is flooded, waterlogged, frozen or snow-covered. Distance requirements for application near bodies of water and slopes. Incorporation of organic fertilisers within 4 hours of application (February 2025: 1h) Organic fertilisers: applied amount of total nitrogen on average of the farm's agricultural land maximum 170 kilograms of total nitrogen per hectare and year. From 1 February 2020, liquid organic fertilisers may only

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			be applied to the soil in strips or directly into the soil in the case of cultivated arable land. Grassland: February 2025
Information	Information seminars for farmers about regulations. Advisory services to integrate regulations in farm management.	Events for the public, advice for farmers, promotion of knowledge transfer and networks.	Information seminars for farmers about regulations. Advisory services to integrate regulations in farm management.
Description*	1) Minimum soil coverage as a requirement to receive direct payments Minimum soil coverage in sensitive periods of the year directly relates to soil health, as the effect is a reduction of erosion, e.g., the loss of SOC. The target group of the measure is all farmers who apply for payments under the CAP. As part of the Common Agricultural Policy (CAP) from 2023, there are a total of nine standards for the good agricultural and environmental condition of land (GAEC). In addition to the basic requirements for farm management (GAB), they are part of conditionality. Compliance with conditionality is a basic prerequisite for receiving direct payments under the first pillar, agri-environmental and climate measures and the compensatory allowance under the second pillar. If you fail to comply with the GAEC standards, you may be subject to administrative sanctions depending on the offence's type, duration and severity. In the event of a first offence committed through negligence, conditionality-related payments may be reduced by 3%. 2) Impact funds The term impact funds covers a broad group of different funds that contribute in some way to improving soil health. For example, this can be done directly by creating financial freedom for farmers who make extra expenditures for soil health. On the other hand, it can also be done indirectly by promoting knowledge transfer to familiarise farmers with soil-promoting practices or educating consumers. 3) DÜV – Fertiliser Ordinance The regulation affects all farmers who wish to apply fertilisers, soil additives, growing media and plant aids to agricultural land. It pursues the goal of soil health, for example, by reducing nitrate leaching into the groundwater as the amount of nitrogen used is regulated. The second important target aspect is the reduction of emissions from the application of fertilisers. Non-compliance with the regulations leads to fines. Non-compliance with the upper application limit for nitrogen, i.e. no more than 170 kg N/ha		

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	per year on average for agricultural land, leads to a fine of € 50,000, for example.

3.2 Policy narrative

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

Policy narrative (and scale of action)	**Policies and incentives in place**	**Land tenure and contracts**	**Management strategies applied**	**Soil functions interested**	**Ecosystem services addressed**
Local and Regional Sustainability (Local)	CAP subsidies for organic certification; RD&D grants	Long-term contracts with Riscal winery; private land tenure	Organic soil enrichment, reduced chemical use	Nutrient transformation, habitat preservation	Food production; water filtration; habitat provision; carbon sequestration; preservation of cultural landscapes
Regional scale of action (Farmers only in the federal state of Baden-Württemberg), but global effect in reduction of atmospheric CO2.	Policies: GAP, AECS → only additional efforts on top can be remunerated. Incentives: Impact funds, GAP, DüV	Farmers are in possession of the land.	Intercropping, crop rotation, organic fertilisers, crop management, permanent crops (energy crops), LUC, soil additives	Carbon storage, soil density	1, 2, 3, 4, 7

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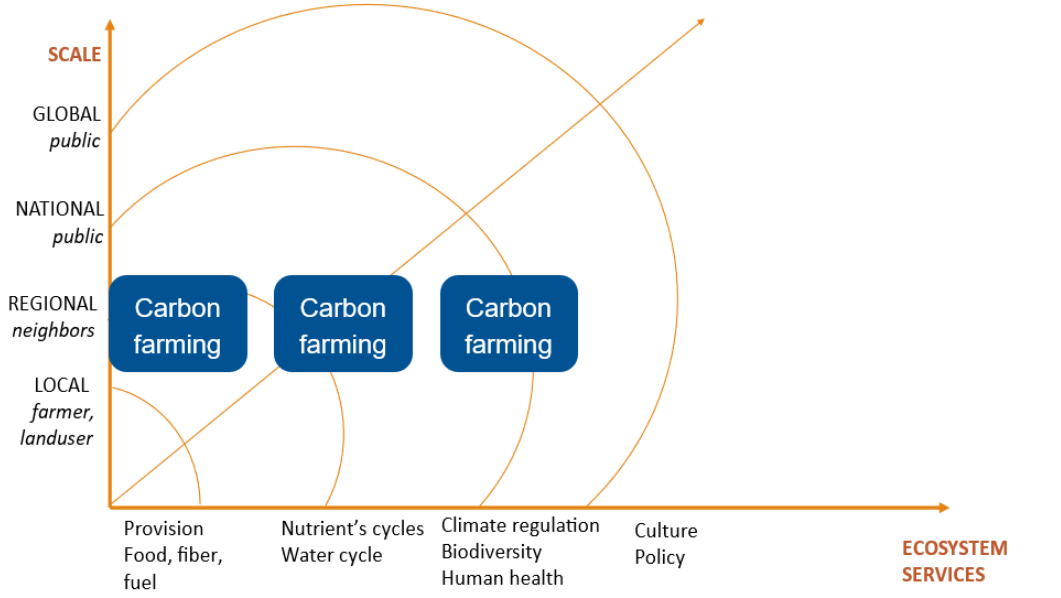

4 Mapping exercise

4.1 Synthesis of the value mapping

a. Value proposition (look at pentagonal problem)

- What are the causes of degradation?

Intensive farming

- Impoverishment of crop and variety selection
- Excessive use of pesticides and mineral fertilisers
- Soil compaction
- Land Use Change

Climatic changes (e.g. extreme weather events)

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

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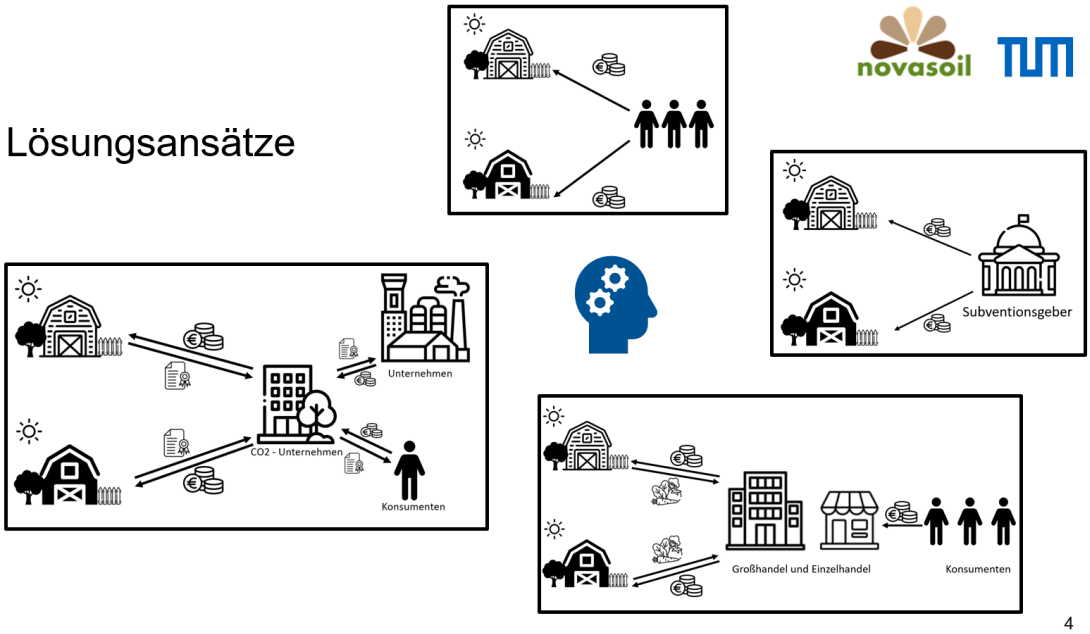

BM1: Carbon farming with intermediaries
BM2: Funds for soil health increasing production
BM3: Payments for ecosystem services
BM4: Value chain approach, e.g. Labels

- Why do soils matter in the BM?

Until now, the trend in agriculture has been toward intensification. Narrow crop rotations with a high proportion of humus-consuming crops have led to a steady reduction in the SOC content of agricultural soils in many areas. Soil life and humus content is also impacted by intensive tillage such as ploughing of the soil in order to suppress pests and weeds. Also, climatic changes lead to increase in the frequency of extreme weather events such as heavy rainfall which can additionally lead to a reduction in SOC content (for example, the removal of the humus layer of the soil by erosion caused by heavy rainfall or storms).

b. Value creation and delivery

- What soil ES are targeted by the business model? (list based on soil strategy)
- What soil ES are not provided / neglected?

Post its:

- *provide food and biomass production, including in agriculture and forestry;*

Farmer	Yes, if you produce biomass that you can market to end customers or industries (e.g. biogas) and in return, you can buy compost from the money you earn in the company.
Farmer	Yes. The production of food is generally ensured. However, an adequate supply of nutrients is

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	important. Humus formation is only important when a combination of nitrogen and carbon is used. Especially in red areas (remark: zones with stricter restrictions on fertilizer input due to high nitrate contents in groundwater), there could be a decline in yields.
Case study	Yes, the humus programme does not essentially change food production, but optimises it in the sense of humus build-up, applicable to all forms of production (organic, conv. etc.).
Case study	Yes. Preservation and promotion of the soil's productive capacity through humus build-up and preservation.
Association	Rather yes. However, the quantity and type could vary (depending on the design of the crop rotation).
Association	Yes.
Researcher	Yes. Diversification of crops, production of biomass, increased soil fertility, source of income, circular economy

- *absorb, store and filter water and transform nutrients and substances, thus protecting groundwater bodies;*

Farmer	Yes, definitely, as long as the soil is covered and erosion is avoided.
Farmer	Yes. If SOC is actually built up, then more water can be stored. Less leachate also means less nitrate losses.
Case study	Yes, the direct effect of higher SOC is water storage and nutrient binding or better nutrient dynamics.
Case study	Yes. SOC contents have direct and indirect positive effects on water balance through aggregate formation; due to more stable aggregates, humus-rich soils are also more able to absorb water without silting up. SOC-rich soils are characterized by high biological activity, which accelerates the degradation and conversion of pollutants.
Association	Yes, crop rotation with SOC enrichment on average across all crops has a positive effect

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Association	Yes, for ecosystem services such as catch crop cultivation, organic fertilization/humus formation, biochar use, crop rotation design, soil cover.
Researcher	Yes. Increased soil fertility, reduced erosion, water filtration, conversion of substances and nutrients.

- *provide the basis for life and biodiversity, including habitats, species and genes;*

Farmer	Yes, of course, but you have to mention that in my opinion there is already too much set-aside and that it should really be positioned in a more concentrated and thoughtful way.
Farmer	No. In principle, production will also be in the foreground in this business model.
Case study	Yes, agricultural measures for humus build-up require better/more diverse crop rotations, maximum soil cover, catch crops/undersown crops and thus directly promote biodiversity
Case study	Yes. Biodiversity is promoted through catch crops, organic fertilisers, wide crop rotation and soil that is always covered as far as possible.
Association	Rather yes.
Association	Support the basis for life/biodiversity (result-oriented agri-environmental measures).
Researcher	Yes. Improvement of soil quality, biodiversity and biodiversity.

- *act as a carbon reservoir;*

Farmer	Yes, definitely, because growing organic matter stores it.
Farmer	Yes. If carbon certificates are awarded, then this should only happen if the humus content in the soil is actually increased in the long term. Then CO2 is also stored.
Case study	Yes, monitoring of the Corg is carried out by soil samples for the entire period of 10 years with preliminary expected values, which are then corrected according to the soil sample result.

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Case study	Yes. More humus means more C in the soil and thus creating a reduction for unavoidable residual emissions.
Association	Yes, preservation of humus acts as storage. Additional storage effect, however, only through additional build-up.
Association	Yes, e.g. via renewable raw materials, miscantus, silphium.
Researcher	Yes

- *provide a physical platform and cultural services for humans and their activities;*

Farmer	Yes
Farmer	No, the focus is on production.
Case study	Yes, the management methods such as catch crops, undersowing, diverse crop rotations, etc. are more colourful and lively and create a more attractive landscape
Case study	Yes. Diverse and diverse agricultural landscapes are attractive recreational areas due to flowering aspects, diversity of crops and the preservation of functioning agriculture in rural areas, landscape conservation communities.
Association	Probably not.
Association	No. Cultural services (e.g. recreation) are also provided without agri-environmental measures. A flower strip, hedge, etc. is not absolutely necessary for this.
Researcher	No, since it is more of an agricultural practice.

- *act as a source of raw materials;*

Farmer	I hope not.
Farmer	No. An intact soil cannot serve as a source of raw materials.
Case study	No, not directly, there is a conflict between agricultural use and raw material use.
Case study	No. Rather not raw materials in the traditional sense, but raw materials of the bioeconomy. Permanent crops such as miscanthus can provide

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	raw materials and regenerate soils; as well as hedges and agroforestry elements.
Association	In principle, yes, but all effects are lost when site is subsequently used as e.g. gravel quarry lost.
Association	No. Do not act as a source of raw materials, but protect them.
Researcher	No. If so, then in an indirect way.

- *constitute an archive of geological, geomorphological and archaeological heritage*

Farmer	Yes, you could say so.
Farmer	Yes, but only as an archive that will not be opened.
Case study	Maybe (this is unclear), deep rooting and reduced tillage can possibly create or allow a classic/typical soil horizon to develop, that would be a task.
Case study	No, not applicable because it does not take effect so quickly. The duration of the business model is 10 years.
Association	Yes, there should be no restrictions on such previous uses.
Association	Yes. Protection of this foundation.
Researcher	No. No preservation of the points mentioned

- Public/private - who can benefit from those values?
  - For farmers, the build-up of humus can improve yield stability. This increases resilience, improves the state of aggregation, reduces tillage and improves drivability and waterlogging.
- What trade-offs emerge? Are the causes addressed?
  - Yield humus ←→ build-up
    The primary goal of farmers is still yield. Farmers are therefore wondering whether humus build-up and the practices necessary for it improve or even deteriorate yields. One example is undersowing in maize. Site conditions are very different, so it is not possible to determine in general whether undersowing affects the yield of maize negatively. Ultimately, farmers have to test this themselves under their conditions.
  - Yield stability ←→ Yield level
    While humus-building practices improve yield stability, yield levels may decrease.

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c. Value capture

- What soil ES are targeted by the incentives?
  Are the incentives aimed at soil health?
  GLÖZ6

	Yes	No
Farmer	x	
Farmer	x	
Case study	x	
Case study	x	
Association	x	
Association	x	
Researcher	x	

DüV

	Yes	No
Farmer		x
Farmer		x
Case study	x	
Case study	x	
Association		x
Association		x
Researcher	x	

Impact funds

	Yes	No
Farmer	x	
Farmer	x	
Case study	x	
Case study	x	
Association		x
Association		X
Researcher	x	

- How is value distributed along the stakeholders?
- Where do the resources come from (public/private)?
  GLÖZ 6: public
  DüV: public
  Impact funds: either private or public.
- How is soil health described and framed by the business model? (place in the picture)

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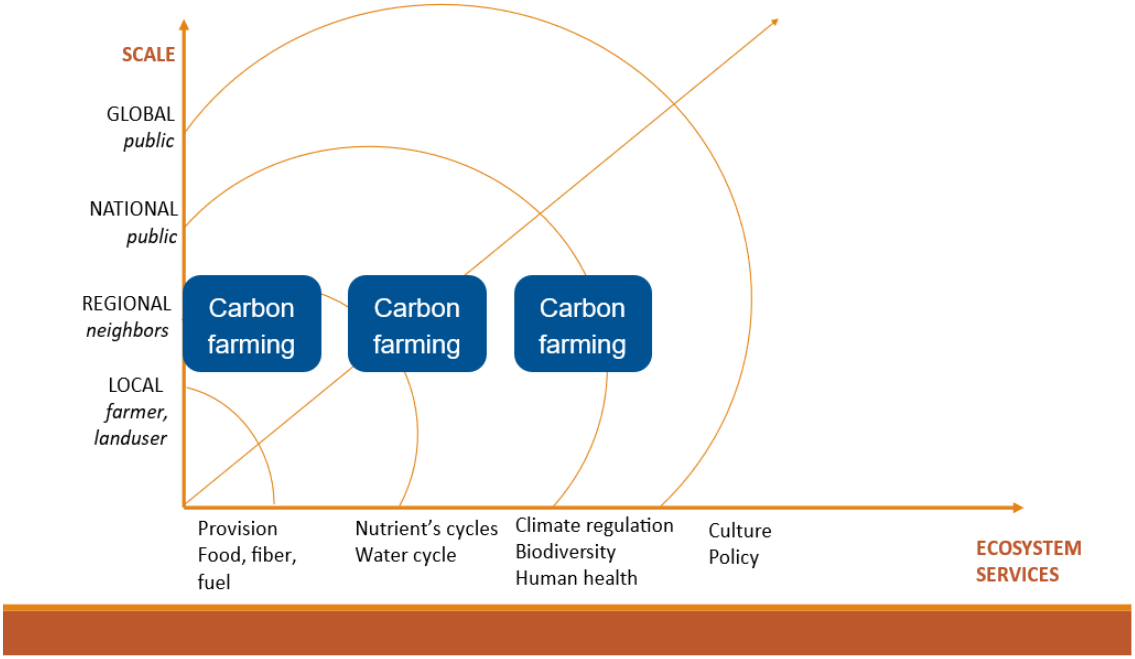

4.2 Solution mapping synthesis

Finally, participants to the workshop are asked to discuss the needs changes for the development of soil health BM and frame them on a temporal scale.

a. What innovations and changes are we looking for?

- Innovative **measurement techniques**: It is crucial for the BM to measure the change in soil carbon content. Soil sampling is very costly and sometimes inaccurate, e.g. if the bulk density is not taken into account, or if the location of the sampling does not remain exactly the same. New, cost-saving technologies were to be developed here. Examples are remote sensing, soil readers, which measure the C content of the soil while driving. It should be noted here that the algorithms of these sensor measurements must be tested for several years in order to function reliably.
- **Research**: It is important to invest in research into humus-stabilizing additives. For biochar, for example, there is hardly any scientific evidence for the effect. Currently, multi-year trials are already being carried out, the results of which could be published in the next few years.
- **Cooperation**: Impact funds such as CO2 Land cannot carry out research themselves, as mentioned above, because the capacity is lacking. However, the funds offer a network of interested innovative farmers who could implement cooperation with research.
- **Promote co-benefits**: Until now, strict care has been taken to avoid double funding of a measure. If a farmer participates in PES and is rewarded by this for providing biodiversity, he cannot be rewarded at the same time for carbon sequestration caused by the practice already remunerated by the PES. Co-benefits are also excluded. If a farmer builds up humus, this is compensated, but not the positive co-benefits

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such as a better water balance or biodiversity. In a model that allows the stacking of different benefits, fair remuneration is to be created here (for example, as it is allowed for in Switzerland).

- **Behaviour**: Younger farmers are more willing to participate in carbon farming because they are more familiar with sensors etc. and are more willing to invest in this respect. But you also have to show the farmers positive aspects. Don't change your behaviour (every farmer wants healthy soils, that's the basis of production), you should use good examples to show that you can make a difference. --> Regionality is again important for comparability.
- **Create transparency**: Depending on the initiative, the information on how many tonnes of C can be sequestered per hectare in a year currently differs. The specifications range from 1 to 8 tons. This casts doubt on the credibility of the statements. For buyers, it is also not clear whether the purchased ton of CO2 has really been sequestered. You need an EU-wide quality standard with transparent measurement techniques.

b. What regulatory and policy conditions would we need?

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

  Rules for uniform **measurements** also between the initiatives, so that measurements, e.g. of the humus structure, are uniform. Time of sampling, what soil condition, measurement method, soil density (determine storage density, but this is extremely expensive). Modeling of the C-setup is also allowed, but you have to prove through validation that the method is reliable. Reliability must be proven.

  There should be a uniform framework for all initiatives so that individual initiatives do not envy everyone because of unreliable statements. Example: Georeferenced soil sampling, at exactly the same location, so that fluctuations of soil characteristics within plots do not affect the value.

- Is there some contradictions between tools and/or policies?
- What could be the effect of the soil monitoring law?

  Negative experiences of farmers, too much bureaucracy and too many regulations. Otherwise, you won't find widespread acceptance. Although we need uniform rules for measuring carbon change, farmers must not restrict and restrict them too much.

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

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Security → Planning security for the future (no false promises, constant innovations, no reliance on new regulations) Define clear goals, in the long term.

Uniform regulations for all carbon farming initiatives regarding the measurement of the change in carbon content in the soil.

c. What resources could facilitate the change?
Capabilities: Ground Measurements
Knowledge: Research, knowledge of humus effects of the practices
Partners: Cooperation Impact funds and research institutes.

4.3 Pathways mapping

Table 4 Pathways mapping

	Short term (up to 3 years)	**Medium (3 - 7 years)**	**Long term (after 7 years)**
INNOVATIONS			
Regulations and binding policies	By the end of 2025, there is to be a standard at EU level for programmes such as CO2 Land	N.A.	Long-term, clearly defined goals that don't constantly change course.
Incentive instruments	N.A.	Research, knowledge of positive effects	N.A.
Contractual solutions	N.A.	**Co-benefits** should also be remunerated.	N.A.
Infrastructure	Clear rules, but keeping bureaucracy low for farmers.	N.A.	N.A.
Product	Transparency	N.A.	N.A.
Services	N.A.	N.A.	N.A.
Technology	N.A.	Innovative carbon content measurement techniques	N.A.
Institutions	N.A.	N.A.	N.A.
Actors' configuration	N.A.	N.A.	N.A.

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Coordination mechanisms and partnerships	N.A.	Cooperation between impact funds and research	N.A.
RESOURCES			
skills, knowledge, R&D	Research, knowledge enrichment on the effects of humus-promoting practices	Cost-effective soil measurements; Cooperation between impact funds and research	N.A.
DRIVERS: social habits, economic, environmental	Good remuneration for the humus contribution	N.A.	Planning security, long-term strategies and goals

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