CLIMATE-FRIENDLY PRACTICES ON YOUR FARM

A PRACTICAL MANUAL

Editor and Publisher

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Contents

FOREWORD

Dear farmers, farm advisors, policymakers,

Dear EU citizens,

Extreme temperatures and weather events during the last springs and summers have left no doubt about the relevance of climate change for the agriculture sector. Climate change is an issue that needs fast, efficient and easy to implement measures that help to reduce agricultural greenhouse gas emissions (GHG) in the European Union and at the same time, help farmers adapt to adverse consequences of unavoidable climate change risks.

Further, other important sustainability goals, such as the protection of biodiversity, healthy water bodies and animal welfare should not be neglected at the cost of a better greenhouse gas emission balance. Between 2013-2018, the project SOLMACC (**S**trategies for **O**rganic- and **L**ow-input-farming to **M**itigate and **A**dapt to **C**limate **C**hange) demonstrated on 12 farms in Italy, Germany, and Sweden that climate-friendly and resilient farming is possible and can provide valuable ecosystem services.

This brochure shows why organic farming has the potential to reduce GHG emissions in the EU and how SOLMACC farmers implemented diverse climate-friendly and resilient farming practices on their farm. Last, but not least, recommendations for farmers and farm advisors are given and further reading materials are presented.

We hope that you enjoy the provided material and wish you an exciting learning experience about climate-friendly and resilient farming practices in the EU!

Cordially,

Your SOLMACC team

CLIMATE CHANGE, AGRICULTURE AND THE FOOD SYSTEM

While climate change has been on the political agenda for many years, few things were achieved for the farmers in the European countryside. With increasing pressure, farmers struggle more and more with harvest losses, damage, and insecurity due to climate change effects and risks. Rising temperatures, extreme weather events and higher pest and disease pressure leave farmers particularly vulnerable if the current agricultural system does not adapt. This is true for farmers all over Europe. Even when, the effects might be more visible in southern countries, like Italy where droughts and heat in the summer months destroy the harvests of whole regions regularly. However, also other countries, like Sweden and Germany which like to count themselves as "climate change winners" suffer under climate change effects. Even when it is argued that the rising temperatures enable the farmers to grow a larger variety of crops for a more extended period, extreme weather events can destroy whole harvests.

At the same time, agricultural production systems contribute significantly to greenhouse gas (GHG) emissions in the European Union. More than 10% of the anthropogenic GHG emissions in the EU derive directly from agricultural production. Additionally, embedded emissions from deforestation abroad for crop and livestock production, food processing, transportation, and waste contribute to an even higher number of total GHG emissions. Internationally, from one third to half of the global GHG emissions derive from the food system.

This share needs to be reduced through a collaborative effort, and organic farming can lead the way. While agriculture is more often seen as part of the problem, it can also be part of the solution. The more farmers apply climate-friendly practices, the more chances we have to prevent dangerous climate change. At the same time, climate-friendly practices must sustain farmers' livelihoods, and a farmer's GHG reductions should not entail a decrease in farm income. Instead the uptake of climate-friendly practices, as part of a more comprehensive sustainability agenda, should be seen as the best way to support farm resilience and to enhance societal expectations of agriculture concerning climate action.

The project SOLMACC (**S**trategies for **O**rganic- and **L**ow-input-farming to **M**itigate and **A**dapt to **C**limate **C**hange) sets out to demonstrate the impact that climate-friendly practices can have. It promotes wider adoption of innovative practices that can contribute to the EU achieving its objectives for climate change mitigation and adaptation in the food and farming sector while considering the economic costs and gains from the practices.

12 motivated organic farmers across Germany, Italy, and Sweden, with four farms in each of the three countries (see Map 1) were part of the SOLMACC demonstration network for climate-friendly and resilient practices. The farmers contributed land, equipment, and labor, and shared their experiences of applying newly-acquired knowledge for climate change mitigation and adaptation in the EU.

Map 1: The 12 SOLMACC demonstration farms

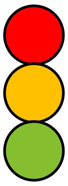
THE SOLMACC DEMONSTRATION FARMS

Each SOLMACC farm applied four agricultural strategies to reduce greenhouse gas emissions; optimized on-farm nutrient management, crop rotations, tillage management and agroforestry. Each practice was evaluated for their climate change mitigation and adaptation potential, as well as their socio-economic and technical feasibility, and associated co-benefits. In this brochure, you will find the description of each farm and the four implemented practices of each farmer.

MITIGATION POTENTIAL

The greenhouse gas mitigation potential is described via a traffic light system. The reduction is described as a percentage change of the initial farm situation. E.g., if the manure was dumped as a manure pile (initial situation), now the farmer composts (improved practice) and thus GHG emissions are reduced by 49 % on average by this practice. For the crop rotation and improved tillage management, GHG emissions were calculated among the whole crop rotation.

The colors indicate the following changes:



Red: GHG emissions were not reduced with the new practice
Yellow: GHG emissions were slightly reduced by minus 1-10%
Green: GHG emissions were significantly reduced with the new practice by more than minus 10 %

ADAPTATION POTENTIAL

Additionally, each practice was validated by the farmers for their climate change adaptation benefits. The two checked boxes indicate the benefit for each practice. For each benefit, one point was given. In total, a maximum of two points was given for the climate change adaptation benefits:

☒ **Crop yields**: no change or increase→ one point was given. If yields decreased no point was given.

☒ **Soil parameters** (compaction, humus content, water holding capacity): no change or improvements according to farmer statement→ one point was given. If soil quality declined with the practices, no point was given.

ECONOMIC VIABILITY

Further, the economic viability of the practices was assessed according to the SOLMACC farmers experience within the project duration (2013-2018). A maximum of three points, represented as **€€€**, for the different income and costs factors were given for:

Crop yield changes: if the crop yields did not change or increased → one point was given. If they decreased no point was given.

Operational & input cost changes: if the operational & input costs did not change or decrease → one point was given. If the costs increased no point was given.

Labor costs: if the labor costs did not change or decreased → one point was given. If the costs increased no point was given.

Last, co-benefits associated with the implemented practice are shown, and practical guidelines and experiences of the farmers are shared.

THE SOLMACC FARMS

Johannes Kreppold: New Manure Treatment

Farm Description

The Bioland farm Kreppold lies 500 m above sea level in southern Germany. With an average annual temperature of 7,5°C and a mean annual rainfall of 750 mm, a lot of arable crops are suitable for the farm. On his 120 ha of sandy to loamy soils the farmer Johannes Kreppold cultivates legumes (36 ha), cereals (42 ha), field vegetables (3 ha), green manure/grassland (35 ha) and forest (7 ha). The suckler cow herd (40 GV) adds up to a traditional mixed farming system.

Farmer Statement

"Climate change mitigation and adaptation is the essential topic of our time, and organic farming plays a forerunner role. Through participating in the SOLMACC-Project and the results thereof, I want to gain a feeling for the right balance between reasonable yields and C-sequestration. The results of the project shall be used on my farm for possible improvement."

Nutrient Management

Johannes Kreppold started **composting his farmyard manure together with green residues from his farm** (e.g., hedge cuttings, weeds). Since 2015, he experiments with an innovative anaerobic treatment (Microbial Carbonisation). He spreads the material on some cultures (maize, winter wheat, beetroots) and thus **helps to close on-farm nutrient cycles.**

CO_2-eq. Reduction: **- 49 %**
Composting farmyard manure helps to reduce CH_4 and N_2O emissions, compared to the emissions of a manure pile under anaerobic conditions.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Composts:

- Reduces the number of viable seeds in the fertilizer as well as soil erosion.
- A stabilized organic matter.

Economic Viability: €
Johannes Kreppold´s experience shows that the compost increased his crop yields. The input, operational and labor costs went up slightly.

Further Information: The mitigation potential refers to a standard composting practice (3 times turning of the material). The MC treatment performed by Johannes Kreppold is a very innovative approach, not tested sufficiently to assess its GHG mitigation potential. However**, this treatment does not require any turning of materials**, which helps to reduce fossil fuel consumption. Nevertheless, further research is needed to get to know the procedure more detailed.

Crop Rotation Management

Johannes Kreppold changed parts of his crop rotation management. He **increased the grain legume production** (soya bean and field beans) from 0% to more than 21% of the arable area. Together with the **forage legume production**, 38% of arable land is cultivated with leguminous crops.

CO_2-eq. Reduction: **- 12 %**
Leguminous crops contribute to N fixation and therefore, reduce the amount of fertilizer needed in the following years.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Legumes:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €€€
Johannes Kreppold's experience shows that with the changes in his crop rotation management, yields and all associated costs did not change.

Further Information: For drying his soybeans, Johannes Kreppold **utilizes the heat waste of a nearby biogas plant**. Depending on the crop, the drying requires large quantities of energy (fossil fuels). By utilizing the heat waste of renewable energy production for the drying process, further CO_2 emissions can be avoided.

Tillage Management

Johannes Kreppold **reduced the depth of tillage** from 15-20 cm to 10-15 cm for nearly all of his arable crops (except winter wheat).

CO_2-eq. Reduction: **- 12 %**
Reducing the depth of tillage helps to reduce fossil fuel consumption.
Climate Change Adaptation Benefit: ☒☐

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€€
Johannes Kreppold's experience shows that crop yields were maintained and at the same time input/operational and labor costs were reduced. In the long term, higher water retention capacity of the soils is essential to him.

Further Information

To reduce the depth of tillage on his farm, he **constructed special machinery**, adapted to his local soil conditions. Therefore, he could minimize weed pressure and maintain crop yields as before.

Agroforestry

Johannes Kreppold uses parts of the renewable energy source of his forest wood for **substituting fossil fuel based house heating**. Additionally, he planted 1 ha of hedges. The shredded hedges are used as a material for the MC treatment (see above).

CO_2-eq. Reduction: 77 t CO_2 eq. saved by using wood instead of heating oil and 16 – 55 t C/ha sequestered annually in the soil, tree biomass and hedge biomass.
Trees and hedges help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.
Climate Change Adaptation Benefit: ☒☐

Co-benefits of Woody Elements:

- Living habitat for diverse animals (biodiversity protection).

Economic Viability: €€€
Johannes Kreppold's experience shows that crop yields were maintained, while input/operational and labor costs did not change with the practice

The MC treatment of farmyard manure

Johannes Kreppold tests a special way of farmyard manure treatment, the microbial carbonization process. For this, he mixes his fresh farmyard manure (around 30-40% mass weight) with materials high in lignin, such as wood chips. The material should be mixed and formed to a trapezoid pile with 1.5 m to 2.5 m in height. The moisture content should be around 50%, which can be best tested if the hands are a little bit moist after the material is touched with light pressure. After the pile is established once, the material is neither turned nor covered. After around 6-8 weeks, the material is ready to be used as a fertilizer. The MC-process offers a good opportunity to integrate wooden waste from the forest and the hedges as a valuable source of C to stabilize N before bringing it to the field. The process can be realized without specialized machinery and with minimum additional effort, both of which make it very feasible.

Pfänder Farm: Innovations on a Stockless Farm

Farm Description

Pfänder farm is a stockless organic farm since 1998. It is located at 560 m above sea level and has an average annual temperature of 7,6⁰C and a mean annual rainfall of 700-800 mm. Though it is in the neighborhood of the Bioland farm Kreppold the farm's nearly 60 ha of loess clay soils and alluvial soils are managed quite differently. On 54 ha the Pfänder family grows field vegetables, clover grass, cereals. Additionally, 1.5 ha of structural landscape including hedges and forests and 3 ha of permanent grassland belong to the farm.

Farmer Statement

„Even a farm without animal husbandry can grow high-quality food and maintain soil fertility with the farm's own fertilizers." Johannes and Florian Pfänder

Nutrient Management

The farm produces **green compost** from different on-farm sources, such as forage legumes, waste from vegetable processing, straw, and soil from carrot washing. The compost is regularly turned and used as a fertilizer for all fields. Therefore, this **helps to close on-farm nutrient cycles.**

CO_2-eq. Reduction: **- 49 %**
Composting green manure helps to reduce CH_4 and N_2O emissions, compared to the emissions of a residue pile under anaerobic conditions.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Compost:

- Reduces the number of viable seeds in the fertilizer as well as soil erosion.
- A stabilized organic matter.

Economic Viability: €€
The experiences from the Pfänder farm shows that crop yields increase with the application of compost, while operational/input costs decreased. At the same time, labor costs increased slightly.

Crop Rotation Management

The farm **introduced leguminous crops** at 25% of the total arable land. Before cultivating green manure leys, broad beans, field peas and soya, they cultivated on this area maize (13 ha).

CO_2-eq. Reduction: **- 7 %**
Legume crops contribute to N fixation and therefore, reduce the amount of fertilizer needed in the following years.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Legumes:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €€€
The experiences from the Pfänder farm shows that yields can be maintained even when growing high-quality vegetables. Operational/input and labor costs did not change.

Tillage Management

The Pfänder farm tested a **no-tillage approach for some crop cultures** (winter wheat, oats, spelt) with a total area of 19 ha. Before SOLMACC, these cultures were tilled annually with a depth of 15-25 cm.

CO_2-eq. Reduction: **- 1 %**
Reducing tillage helps to reduce fossil fuel consumption.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€€
The experiences from the Pfänder farm shows that crop yields and labor costs did not change with the new practice. At the same time, operational costs decreased.

Agroforestry

Family Pfänder **planted hedges and tree strips** (0.61 ha) and cultivated around 1 ha of forest. Parts of the renewable energy source of their forest wood is used for **substituting fossil fuel based house heating**.

CO_2-eq. Reduction: 5.2 t CO_2 eq. saved by using wood instead of heating oil and 5-29 t C/ha sequestered annually in the soil, tree biomass and hedge biomass.
Trees and hedges help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.
Climate Change Adaptation Benefit: ☒☐

Co-benefits of Woody Elements:

- Living habitat for diverse animals (biodiversity protection).

Economic Viability: €
The experience from the Pfänder farm has shown that crop yields did not change.

The in-situ mulching system

One technique used by Bioland Pfänder farm is the in-situ mulch of broad beans in growing field vegetables. The broad beans form a temporary mixed seed. They improve the structure of heavy and often wet soils in spring, suppress weeds and supply nitrogen to the main crop. At the same time, the mechanical hoe can be used without problems.

All machines for the cultivation of field vegetables have a working width of 3 m. With a simple mechanical seed drill with 12.5 cm row spacing, the farmers sow four rows of field beans in 3 to maximum 4 cm placement depth. In between these, there are two empty rows where no beans are sown. Like this 400 kg of the broad bean is sown per ha. The shallow placement depth is essential to ensure that the field bean can be killed reliably with a row tiller later on. In heavy wet soils, the shallow sown bean grows without problems. Two weeks later, when the soil has settled, the farmers plant or sow field vegetables - cabbage, celery, leek, broccoli or cauliflower - in the empty rows. The cultivator hoe along the row of field vegetables is no problem, while the field beans, which are not chopped yet, continue growing. If the broad beans are 20 to 30 cm tall, they are worked into the soil with a Comeb row tiller that is set to 5 to 6 cm working depth, i.e. deeper than the seed placement, so that the seed grain is chopped out as well to make sure that the bean plant is completely killed and sets free its N to fertilize the vegetables. The field bean should not be larger than 40 cm so that the row tiller works smoothly. Depending on the culture and the in-row weed pressure, weeds there are covered with a trailing ridging hiller unit. Like that the weeds are well regulated in all areas Depending on the crop and weed situation, the farmers use the row tiller a second time after a while, sometimes combined with the ridging hiller unit.

Gut Krauscha: Synergies of Adaptation & Biodiversity

Farm Description

On the Bioland farm Gut Krauscha, Hans-Joachim Mautschke manages around 300 ha of land. His main production is cereals (79 ha), clover grass (54 ha) and legumes (26 ha) beside his permanent grassland (120 ha) and more than 11 ha of hedges. With the beginning of the SOLMACC project, he additionally kept around 70 cows but stopped animal husbandry in 2018.

Farmer Statement

"For a farm in the eastern rim of Germany the exchange of experiences is of utmost importance. I want to make use of the changes the project delivers in terms of connections. Hence, it would be important for me to meet my colleagues from Germany but also from Sweden and Italy."

Nutrient Management

The farmer composted the farmyard manure from his 70 cows. The produced compost was spread on the most of his arable fields once per year. Therefore, the compost application helped him **to close on-farm nutrient cycles.**

CO_2-eq. Reduction: - 49 %
Composting farmyard manure helps to reduce CH_4 and N_2O emissions, compared to the emissions of a manure pile.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Compost:

- A stabilized organic matter.
- Helps to reduce soil erosion.

Economic Viability: €
The experience at the Gut Krauscha farm shows that crop yields and operational costs could be maintained with the new practice. At the same time, input and labor costs increased slightly.

Crop Rotation Management

The farmer **introduced grain legumes** (field peas and lupines) on 16% of his arable area. Additionally, he **extended the clover ley cultivation from one to two years** in his crop rotation. By this, 50 % of his arable area is now cultivated with leguminous crops.

CO_2-eq. Reduction: - 7 %
Legume crops contribute to N fixation and therefore, reduce the amount of fertilizer needed in the following years. By extending the clover cultivation, practices, such as plowing are done only once every two years instead of every year. This helps to reduce fossil fuel consumption.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Legumes:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €
The experience at the Gut Krauscha farm has shown that crop yields and operational costs could be maintained with the new practice. At the same time, input and labor costs increased slightly.

Tillage Management

Some cultures were managed **without plowing** (clover, lupine), while for winter wheat and rye the **depth of tillage was reduced** from 20-25 cm to 10-15 cm. In total, on 86% of the fields, tillage was reduced.

CO_2-eq. Reduction: - 0.1 %
Reducing tillage helps to reduce fossil fuel consumption.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €
The experience at the Gut Krauscha farm has shown that crop yields and operational costs could be maintained with the new practice. At the same time, input and labor costs increased slightly.

Agroforestry

On the farm around 11 **ha hedges and tree strips were planted**. Part of the woody biomass (as wood chips) is used to **substitute house heating with fossil fuels**.

● **CO_2-eq. Reduction**: **206 t CO_2 eq. saved by using wood instead of heating oil and 107-211 t C/ha sequestered annually in the soil, tree biomass and hedge biomass.**

Trees and hedges help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.

Co-benefits of Woody Elements:

- Living habitat for diverse animals (biodiversity protection).

Economic Viability: €€

Operational, input and labor costs did not change with the new practice.

A farmer composts his grassland growth, to fertilize his fields

There are important reasons for preparing compost. On the Bioland farm Gut Krauscha, it is the extensively used grassland, which is also to be cultivated by mowing unless the small herd of suckler cows grazes on it. However, the nutrient-rich clippings were no longer to be mulched uselessly, while on the sandy farmland of more than 200 hectares fertilizers had to be purchased in part. Farmer Mautschke tried to transfer nutrients from grassland to arable land via compost from meadow cuttings. Composts from pure plant material promise a balanced nutrient content. Above all, they provide phosphorus and potassium for arable crops and positive effects through humic substances in the soil. Although compost also produces nitrogen, unlike the other nutrients, only about ten percent of it is effective in terms of yield in annual stages. During composting in triangular rents with a height of about 1.5 m, the rotting of the meadow cuttings was challenging to get going. It did not want to form an earthy, black decomposition product. On other farms in the SOLMACC project, it turned out that grass can only be satisfactorily processed with bovine manure or similar additives. According to technical literature, however, an optimum structure and adequate moisture content of the rotting material and adequate nitrogen in the organic material are sufficient. The visit to the composting plant confirmed the literature references. The compost professionals only mix grass clippings with wood chippings to reach the compost through a suitable substrate structure. That is why they wet the rent. Also, the rents are turned several times a week to bring fresh air to the core of the rent. The entire rotting process should take place aerobically so that neither methane nor other harmful gases are formed. Before the compost is delivered, the composting plants screen the compost to 15 mm and use the coarser structural components, usually wood chippings, one more time.

With regard to the climate balance, the wide C/N ratio and the coarse structure of the starting material are favorable for compost. As a result, only a small amount of ammonia and methane is likely to be emitted in the rotting process. Compost is also a complex fertilizer. Farmer Mautschke is aware, however, that he is only relocating phosphorus and potassium in particular with grassland compost and is not creating new ones. However, nitrogen is also included, which is mainly produced by white clover on grassland. It is precisely this nutrient transfer that relieves some arable land of the task, with the help of legumes to have to collect nitrogen themselves. This allows arable farmers to increase their cereal market share.

Kornkammer Haus Holte: Building a Biogas Cooperation

Farm Description

The cattle loose Bioland farm Kornkammer Haus Holte has an average annual temperature of 8.9°C and a mean annual rainfall of 750-890 mm. On a total of nearly 250 ha with mainly loess soil, he cultivates cereals (143 ha), red clover and legumes (54 ha), potatoes (32 ha), permanent grassland (15 ha) and hedges (6 ha).

Farmer Statement

"Through participating in the SOLMACC-Project I hope to find a better adapted management in my plant production. Moreover, the measurements and assessments of the climate relevance of my farm are exiting as well."

Nutrient Management

A cooperation between the farmer and a biogas plant producer was established. The biogas plant received the first cut of the clover grass ley in exchange for biogas slurry. The slurry was brought back to the oat and potato fields and therefore used as a fertilizer to **closer on-farm nutrient cycles.**

CO_2-eq. Reduction: **- 1.3 %**

The application of biogas slurry helps to reduce fertilizer application in the following years. Further, less GHG emissions are emitted when clover-grass leys are cut and carried, instead of mulched in the fields. Last, biogas production helps to reduce fossil fuel emissions for energy and heat production.

Climate Change Adaptation Benefit: ☒☒

Economic Viability: €€€

The experience of the farmers shows that crop yields increased with the practice, while operational/input costs and labor costs decreased.

Crop Rotation Management

The farm **introduced leguminous crops.** Red clover is produced for the biogas plant instead of cultivating maize on the same are (39 ha). Additionally, grain legumes (field beans) were cultivated instead of winter wheat. By this, the area cultivated with leguminous crops increased by 23%.

CO_2 Reduction: **+ 2 %, due to an increase in organic fertilizer usage**

Legume crops contribute to N fixation.

Co-benefits of Legumes:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Tillage Management

Red clover, winter wheat, and spelt are **cultivated ploughless**. Additionally, a ploughless cultivation of potato was tested on 32 ha. Last, the farmer **reduced the depth of tillage** from 20-25 cm to 5-10 cm in oat fields.

CO_2-eq. Reduction: **- 9 %**

Reducing tillage helps to reduce fossil fuel consumption.

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Agroforestry

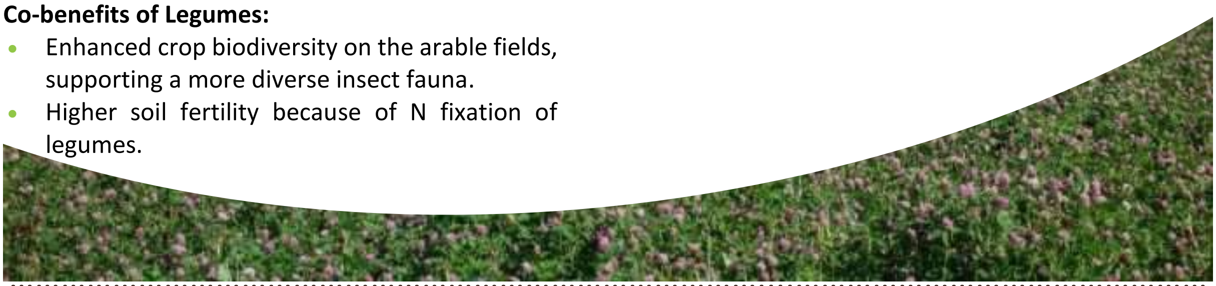
The farm **planted around 3 ha of hedges and tree strips** on their fields. Along with the already existing diverse hedges and trees, around 6 ha are used as boundaries for the arable fields.

CO_2 Reduction: **Around 45-153 t C/ha are sequestered annually in soil, tree biomass and hedge biomass.**

Trees and hedges help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.

Co-benefits of Woody Elements:

- Living habitat for diverse animals (biodiversity protection).



Establishing a Biogas Cooperation

The establishment of a biogas cooperation requires particular attention to implement the specific guidelines in each region correctly. The Bioland enterprise Kornkammer Haus Holte in North Rhine-Westphalia has successfully realized cooperation with a local biogas plant.

Using this successful cooperation as an example, a summary of experience can be given according to which organic farms in North Rhine-Westphalia can enter into similar cooperation. It should be noted that the guidelines of the Bioland Association differentiate between two types of biogas plants. One speaks of **ecogas plants** if a biogas plant belongs to an organic farm and is operated according to the Bioland guidelines**. Agrogas plants** are biogas plants that are operated by conventional companies in accordance with the Bioland Directive.

Basic regulations for cooperation with agrogas plants

- Agrogas plants on Bioland farms are possible if cultivated according to Bioland guidelines
- Bioland farms that cooperate with agrogas plants must take back the quantities of nutrients that have also been added to the plant beforehand. This is only possible in NRW in the form of clover grass and manure (this procedure is tolerated until new regulations in the area of biogas plants are made with the revision of the EU ECO-Regulation).
- The organic farm must prove that it is economically unreasonable for it to contribute to an ecogas plant from which fermentation residues are exclusively or predominantly (>50 %) spread on organic land. The following applies to the proof of this unreasonableness:
    1. If a distance of more than 30 km from the plant to a biogas plant with a share > 50 % of organic substrates is defined (ecogas plant).
    2. A suitable map shall be used to show which ecogas plants (>50 % organic substrate) are available over a distance of 30 km.
- All fermentation materials must be listed in Annex 10.1 (Guideline p. 47) Approved soil improvers and fertilizers as well as substrate components.
- If substrates from non-organic production are used as co-ferments, e.g., maize, in agrogas plants, these must not have been treated with pickling agents from the active substance group of neonicotinoids.
- No GMOs are allowed
- The conformity of these fermentation materials must be documented with proper proof (form Biogas control body).
- The delivery of fermentation residues to organic farms that have not previously delivered clover grass or manure to this plant is not permitted.
- The delivery of fermentation residues to conventional farms is still permissible.

Azienda Agricola Fontanabona: Green Manure Cultivation

Farm Description

The Fontanabona farm is located in the Po' Valley, a few kilometers from Verona and the Pre-Alps. It is about 7 hectares large. The Fontanabona family has been cultivating organically since 1982, but the field has the current characteristics since 1999. About 4 hectares of the land is reserved for kiwi crops (under anti-hail nets), while in the remaining part of the land horticultural products (such as lettuce, celery, cabbage, and chard) are cultivated in a greenhouse.

Farmer Statement

"I want to be involved in SOLMACC project because I want to share knowledge and best practices at European level."

Nutrient Management

Paolo Fontanabona started **composting the farmyard manure** (around 200 t) from a nearby farm together with his **mushroom bed and other on-farm residues**. He spreads the material twice per year on all of his cultures.

CO_2-eq. Reduction: **- 49 %**
Composting farmyard manure and mushroom bed residues help to reduce CH_4 and N_2O emissions, compared to the emissions of a manure pile.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Compost:

- Reduces the number of viable seeds in the fertilizer as well as soil erosion.
- A stabilized organic matter.

Economic Viability: €€€
The farmer's experience shows that spreading the compost increased his crop yields. At the same time, operational/input and labor costs did not change or even decreased.

Crop Rotation Management

Paolo Fontanabona **introduced legume cultivation** on his 3 ha large **greenhouse areas**. He included cowpeas and sorghum on half of the area. Additionally, on his 4 ha kiwi orchards, he **substituted grassland by permanent green manure**, consisting of crimson clover, vetch, white mustard, rye and oats

CO_2-eq. Reduction: **- 50 %**
Legume crops contribute to N fixation and therefore, reduce the amount of fertilizers needed in the following years.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Legumes:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €
The farmer's experience shows that with the changes in his crop rotation management, yields increased largely. At the same time, all other associated costs (operational/input and labor) increased.

In begin of July, the green manure (Sudanese sorghum, Crotalaria juncea and Vigna unguiculate) in the greenhouse is cut and chopped. It is left and dried and afterwards slightly buried in the soil. Afterwards, the soil is prepared for transplanting the seedlings in the greenhouse. By this, the soil fertility could be improved and the farmer could increase his crop yields.

Tillage Management

Paolo Fontanabona **reduced the depth of tillage** from 20-25 cm to 15-20 cm for all his crops. Weed management is done with **plastic mulch that is used for two years and then professionally recycled.**

CO_2-eq. Reduction: **- 13 %**

Reducing the depth of tillage helps to reduce fossil fuel consumption.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€€

The farmer's experience shows that crop yields were maintained and at the same time input/operational and labor costs were reduced.

Agroforestry

Paolo Fontanabona **planted 0.21 ha boundary hedges.** Additionally, 4.30 ha of **orchards for fruit production** was established on the farm.

CO_2-eq. Reduction: **Around 4.5-35.4 t C/ha are sequestered annually in the soil, tree biomass and hedge biomass.**

Trees and hedges help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Woody Elements:

- Living habitat for diverse animals (biodiversity protection).
- Alternative income source for the farmer.

Economic Viability: €€€

The farmer's experience shows that crop yields were maintained, while input/operational and labor costs did not change with the practice.

Using green manure and compost for improving soil fertility

To protect soil fertility on the farm, Paolo Fontanabona established a compost production from on-farm residues. He mixes farmyard manure, green manure, and residues from mushroom production. The manure is composted in three trapezoidal piles 1.50 m high and 30 m long, covered by a polypropylene sheet. Additionally, the farmer uses biodynamic preparations. To avoid anaerobic conditions, the farmer turns the composts regularly. Further, he ensures that coarse materials (such as straw) are present adequately. The high humus yield of manure and compost, the quantities with which they are used and the summer green manure grass, close the annual humic balance with a good profit, producing a progressive increase in the humus reserves of the soil. An excellent contribution to the microbial biodiversity of the soil is also potentially made by green manure. The use of mulching instead of working the soil to control weeds reduces oxidation - and therefore losses - of organic matter.

Azienda Agricola Caramadre: Sudanese Sorghum Grass in the Rotation

Farm Description

The Caramadre farm is located in the Agro Romano, within the National Reserve of the Coast and near the Macchia Grande Reserve of the ***WWF*** Natural Oasis. It includes two different areas: one located in Maccarese (7.5 hectares wide including 2 hectares of cold greenhouses) with mainly fruit production and another area in Torre in Pietra (13 hectares wide). Here, organic crops of several fruits and vegetables (such as broccoli, cabbage, cauliflower, cabbage, summer melons, strawberries, salads, beets, etc.) are planted.

Farmer Statement

"Thanks to the SOLMACC practices, I will play a role in the fight against climate change!"

Nutrient Management

Before the SOLMACC project, the farmer did not use organic fertilizers. Therefore, a co-operation between a livestock holder and his farm was planned. However, all farms were too far away to justify transport and timing for the farmer. Therefore, now the farmer uses his green manure to optimize his nutrient management.

Crop Rotation Management

The farmer **introduced legumes into the crop rotation**. They included green manure, broad bean or field beans. In the greenhouse, crotalaria was introduced as a green manure legume. Together, leguminous crops constitute between 20-30% of the crop rotation.

🔴 **CO_2-eq. Reduction**: **-+17%, as more external fertilizer was used**

Legume crops contribute to N fixation

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Legumes:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €€€

The farmer's experience shows that with the changes in his crop rotation management, yields and all associated costs did not change.

Tillage Management

Before the project, the farmer plowed all of his crop cultures. Now, he **reduced the depth of tillage** for all crops, by only working superficial (with a depth up to 10 cm).

🔴 **CO_2-eq. Reduction**: **-0.5 %**
Reducing the depth of tillage helps to reduce fossil fuel consumption.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€€
The farmer's experience shows that crop yields increased and at the same time input/operational and labor costs were maintained.

Agroforestry

The agricultural areas are surrounded by tree strips of pines and eucalyptus (around 0.08 ha). Their primary function is to protect the agricultural areas against the wind.

🟢 **CO_2-eq. Reduction**: **Around 64-488 kg C/ha are sequestered annually in the soil, and tree biomass.**
Trees and hedges help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Woody Elements:

- Living habitat for diverse animals (biodiversity protection).
- Wind protection.
- Eucalyptus woods chips are used for weed suppression in arable fields.

Economic Viability: €€€
The farmer's experience shows that crop yields were maintained, while input/operational and labor costs did not change with the practice.

Sudanese Sorghum – a heat-loving plant for large biomass production

One of the main problems for the Italian SOLMACC farmers was the soil fertility and nematode management. These were handled by including Sudanese Sorghum in the crop rotation. They produce large quantities of organic matter that are used as green manure. The farmer developed a management system to optimize the use of this plant and therefore improving soil fertility on his farm. He uses between 30-40 kg seeds per ha. His experience has shown that the soil does not need to be overly refined for the sowing, but in case of heavy rain events or too few rains, it is good to roll immediately after sowing. The crops will grow during summer and autumn and crops can be sown in the following spring season. During this time, the grass can be cut two times, where the second time it can be left on the ground throughout the winter. By this, excessive loss of soil organic matter is reduced. Before spring sowing, the biomass should be incorporated into the soil. The farmer has also experimented with a technique where green manure (Leguminosae or Graminaceae) is crushed by a roller crimper and not buried. The vegetable crop is transplanted or sown in furrows produced, thus playing a role of natural mulching with burial at the end of the cycle.

Mannucci Droandi: Permanent Grass & Vineyards

Farm Description

Mannucci Droandi is a family farm located in the hamlet named Caposelvi, about 35 km far from Arezzo. The production is based mainly on **olive oil and wine** according to the standards of organic farming. The farm consists of **two areas**: **Campolucci and Ceppeto**. The former is located on the eastern slopes of the Chianti Mountains at an altitude of 250 m above sea level. The second part of the estate, Ceppeto, consists of vineyards and olive groves surrounded by dense oak and chestnut woodland. It is situated on the west side of the Chianti mountains at 350 m above sea level.

Farmer Statement

"I hope that SOLMACC will spread innovative sustainable techniques and improve farming methods countering climate change!"

Nutrient Management

Compost is produced from marc and prunings from vines (around 1500 – 2000 kg/year), and other on-farm residues. The compost is distributed in vineyards and olive groves and therefore **helps to close on-farm nutrient cycles.**

🟢 **CO_2 Reduction**: **- 49 %**
Composting marc helps to reduce CH_4 and N_2O emissions, compared to the emissions of a residue pile.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Compost:

- Reduces the number of viable seeds in the fertilizer, and soil erosion.
- A stabilized organic matter.

Economic Viability: €€
The farmer's experience shows that spreading the compost increased his crop yields significantly. However, at the same time, more operational costs occurred, while input/labor costs were maintained.

Crop Rotation Management

The farm introduced **green manure with seeding, in the vineyards and olive groove** on 31 ha. The green manure consists of different graminacea, bee pasture (Phacelia) and clover. It is cut 3-5 times a year and utilized for the compost production or directly left on the field as a fertilizer for the vineyards.

🔴 **CO_2-eq. Reduction**: **+5 %, because the practice requires more machinery input**
Legume crops contribute to N fixation and therefore, reduce the amount of fertilizer needed in the following years.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of green manure mixed in vineyards:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €€€
The farmer's experiences show that with the changes in his crop rotation management, yields and all associated costs did not change.

Tillage Management

Farm **avoids plowing on the 31 ha vineyards and olive groves**. Instead, a **permanent grass cover** is cultivated with 2-4 passages per year with spring harrows or disks that are used to aerate the soil.

🟢 **CO_2-eq. Reduction**: **- 26 %**
Avoiding tillage helps to reduce fossil fuel consumption.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€
The farmer's experience shows that crop yields increased significantly, while operational costs increased. Input and labor costs were maintained.

Agroforestry

The farm consists of **8 ha olive groves, 25 ha vineyards and around 1 ha boundary trees** along the fields. The boundary trees were diversified, and new trees were planted (e.g., Robinia and Oak). Additionally, the farmer introduced a rare, nearly extinct chicken breed into the vineyards.

● **CO_2-eq. Reduction**: **Around 27.2-207.4 t C/ha are sequestered annually in the soil, and tree biomass.**
Trees help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Woody Elements:

- Living habitat for diverse animals (biodiversity protection).
- Diversified income source.

Economic Viability: €€€
The farmer's experience shows that crop yields were maintained, while input/operational and labor costs did not change with the practice.

Vineyard Cover - improving soil fertility

The experience of the SOLMACC farmer Mannucci Droandi has shown that a permanent grass cover of the vineyards helps to:

- Increase soil microbial activity.
- Promote a more intense humification process, as the mineralization of the organic substance, is more homogenous.
- Improve soil structure and reduce runoff in case of heavy rain events.

To reduce the operational effort of grass cutting, the growth of the grass must follow the course of the season. At the beginning of the vegetative period, it must be strong to slow down the vigor of the vineyard and stimulate the biological activity of the soil. It must then gradually be reduced until it is no longer needed in the critical summer phase.

Azienda Agricole Tamburello: Olive Groves and Green Manure

Farm Description

The Tamburello farm is placed in the valley of the Belice river, on the "Wine Route" (Palermo-Sciacca), linking up the Tyrrhenian Coast to the Channel of Sicily. It covers about 60 hectares, and the land is very diverse with vineyards, olive groves, and cereal production. It is a family farm with the belief that a healthy soil, cultivated with patience, love, and effort can give life to products of excellence. In addition to the attention to the quality of the products and, therefore, to the choice of implementing the organic farming practices**,** the Tamburello family is particularly sensitive to the environmental issues. The company aims to reduce greenhouse gases emissions, and for this reason, it decided to **install a photovoltaic system providing more than 90% of the company's energy needs**.

Farmer Statement

"Participating in SOLMACC, I would like to be part of a strong European network!"

Nutrient Management

Before the SOLMACC project, the farmer did not use organic fertilizers. Therefore, it was planned to compost wine and olive production residues. However, it was difficult to find a right place for the compost production. Therefore, now the farmer uses his green manure to optimize his nutrient management.

Crop Rotation Management

In the olive groves (15 ha), green forage manure, consisting of a **mixture of leguminous (Trifolium spp.) and Graminaceae, is cultivated**. Instead of leaving the soil coverless. The green manure is cut 1-2 times per year with a shredding machine.

CO_2-eq. Reduction: **- 99 %**
Legume crops contribute to N fixation and therefore, reduce the amount of fertilizers needed in the following years.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of green manure in olive groves:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €€€
The farmer's experience shows that with the changes in his crop rotation management, yields increased, while operational/input costs were maintained. At the same time, labor costs were reduced.

Tillage Management

The farmer **reduced the tillage depth** in the olive groves (15 ha) from up to 20 cm depth to 5-10 cm.

CO_2-eq. Reduction: **- 3 %**
Reducing the depth of tillage helps to reduce fossil fuel consumption.
Climate Change Adaptation Benefit: ☒☒

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€€
The farmer's experience shows that crop yields increased, while all other costs (operational/input/labor) could be reduced.

Agroforestry

The farm has around 5333 vine and around 333 olive trees.

CO_2-eq. Reduction: **Around 28-213.5 t C/ha are sequestered annually in the soil, and tree biomass.**

Trees and hedges help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Woody Elements:

- Living habitat for diverse animals (biodiversity protection).

Economic Viability: €€€

The farmer's experience shows that crop yields were maintained, while input/operational and labor costs did not change with the practice.

Olive Grove Management with a Green Manure Cover

Olive trees require organic fertilizer during two separate phases of the year. First, during April/May for flowering and second, during August for the enlargement of the drupe. The Tamburello farm cultivates green manure with favio (broad bean) to support the olive grove growth during the first phase. With time, the green manure can evolve towards a permanent canopy. In between rotary cutter mowers and cutterbar mowers are used by the farmers, as they are comparatively light in weight and require little energy to function. These are used with a reduced tillage depth of 5-15 cm maximum. By this, root development is not interrupted. However, it is essential to study the local soil first. A prerequisite for the reduced tillage depth is the absence of soil compaction. Then, a reduced tillage depth can help to improve soil fertility and also reduce evaporative water losses, a substantial climate change adaptation benefit for Italian farmers in dry regions.

Hånsta Östergärde: Mobile Livestock Systems

Farm Description

The organic farm Hånsta Östergärde is located about 90 km north of Stockholm. The farmers, Kjell and Ylva Sjelin, cultivate about 160 hectares of farmland with a crop rotation roughly consisting of two years of ley, wheat, oats, peas or field beans, rye, and barley. Additionally, they have 10 hectares of permanent pastures, 57 ha forest and mixed animal husbandry with cattle, sheep, pigs, and hens. Kjell and Ylva are passionate about developing agricultural practices that decrease the amount of carbon in the atmosphere.

Farmer Statement

"Agricultural challenges are that we now must repair the life supporting systems such as a stable climate and beyond producing more food for more people. We want to take part in the implementation of these two tasks.

Nutrient Management

All animals are kept outdoors during the whole year. In winter time they are kept on arable land with access to open, mobile shelters with straw bedding. The sheds are moved when the straw beds are 40-50 cm thick. When they do field operations in the spring, the bedding material is spread and harrowed into the ground. Spreading and harrowing are done simultaneously to get the manure directly in contact with the soil to minimize ammonium losses.

CO_2-eq. Reduction: **- 85 %**

The direct deposition of the manure to the soil minimizes emissions from manure storage.
The transport of manure is eliminated which saves diesel.

Climate Change Adaptation Benefit: ☒☐

Co-benefits of Mobile Livestock Systems:

- Time is saved when the manure does not need to be transported from the farmyard to the fields.
- The farm needs less manure storage capacity which saves concrete.

Economic Viability: €€€

The farmer's experience has shown that crop yields and input, operational and labor costs could be maintained at the same level. Capital is not stock in big buildings and surfaces for manure storage.

Crop Rotation Management

The farm introduced a triticale-winter pea mixed culture. This improves yield stability of peas compared to cropping in monocultures. The protein yield per ha is increased. Also, the farm has maintained that around one-third of the area is cropped with forage legumes in the crop rotation (2 out of 7 years).

CO_2-eq. Reduction: **- 21 %**

Legume crops contribute to N fixation and therefore reduce the amount of fertilizers needed in the following years.

Climate Change Adaptation Benefit: ☒☐

Co-benefits of Legumes:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €€€

The farmer's experience has shown that crop yields and input, operational and labor costs could be maintained at the same level. The winter peas are highly appreciated by the market for human consumption.

Tillage Management

The farm reduces tillage activities by seeding spring and winter cereals simultaneously in the spring. The winter cereal grows slower and stays low until the spring cereal is harvested. It is then overwintered and harvested the next year.

CO_2-eq. Reduction: **- 4.6 %**

Reducing tillage helps to reduce fossil fuel consumption.

Climate Change Adaptation Benefit: ☒☐

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€€

The farmer's experience has shown that crop yields did not change, while input and operational costs could be maintained. At the same time, labor costs could be decreased.

Further Information
The experience of the farmer is that in 1 year out of 4 you need to seed in the autumn due to a weak winter cereal crop. Often the winter cereal becomes weak as a consequence of a high yielding spring cereal crop.

Agroforestry

The farm has established an alley-cropping system on one of the fields. The tree rows consist of hazel, apple, pear and sea buckthorn. Between the rows a regular organic crop rotation is cultivated.

Additionally, during summer, the pigs are kept in the part of the forest that has recently been, or soon will be, logged and by rooting they help the natural re-plantation of the trees while they also fertilize the ground.

CO_2-eq. Reduction: 80-162 t C/ha sequestered annually in soil, tree biomass and hedge biomass

Trees help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.

Climate Change Adaptation Benefit: ☒☐

Co-benefits of Alley Cropping:

- Living habitat for diverse animals (biodiversity protection).
- The fruits from the rows secure a diverse access to food, and income for the farmer.
- Pigs help to reduce the need for soil management in the forest.

Economic Viability: €€
The farmers experience has shown that crop yields and input costs could be maintained, while operational costs decreased. At the same time, labor costs increased.

Mobile Livestock Manure Management

The manure management at Hånsta with animal husbandry on arable land is a promising management strategy resulting in lower emissions and lower investment cost for manure storage. During the winter animals are kept on arable fields with mixed grass with access to movable weather shelters.
Grass silage is fed during the cold season on the grassland. Straw is harvested in nearby fields and stored on the grassland. The manure littered beds are spread on the neighboring grain fields or the winter grassland just before spring tillage. Manure collection starts normally when the grazing is reduced in early November.

Gathering of manure ceases completely around the 10th of May. The collected manure originates from different location types:

- the beddings in the shelters (45%),
- the outdoor beddings on the grassland (25%),
- around the movable silage bale feeders (10%)
- the rest of the manure ends up randomly distributed on the grassland (20%).

Körslätts Gård: The Economics of Establishing Biodiversity Strips

Farm Description

Körslätts farm is located in the most southern region of Sweden, and the farm is organic since the year 2000. Here the farmer Magnus Bengtsson cultivate 130 ha of arable land and has 90 ha forest land. The farm also has the potential of producing 42,000 organic chickens per year in batches of 4,800 animals every five weeks. When there are chickens on the farm, they are kept in mobile buildings in a rotational system within a permanent field.

Farmer Statement

"I think the project sounds interesting and see it as an opportunity to organize the job I already started on the farm. To refine and document the effects of different measures is meaningful."

Nutrient Management

The farm has chicken manure to manage and by introducing a new winter crop, winter oilseed rape, the farm can now utilize the chicken manure collected during summer already in the autumn. Earlier the manure was stored until spring leading to extra emissions of CH_4 and N_2O.

CO_2-eq. Reduction: **- 15%**

Better utilization of farmyard manure helps to reduce CH_4 and N_2O emissions.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Manure Management:

- A new winter crop helps to diversify the crop rotation.

Economic Viability: €€€

The farmer's experience shows that crop yields and all other associated costs (input, operational, and labor) did not change with the implemented practice.

Crop Rotation Management

Magnus Bengtsson changed parts of his crop rotation management. He **increased the grain legume production** (lupin and field beans) and therefore substituted parts of the cereal production. Rape seed has been introduced, which increase nutritional uptake of manure in the autumn. Maize for combine harvesting is introduced with success – an example of a crop that will be possible to grow in a warmer climate in Sweden in the near future.

CO_2-eq. Reduction: **-7 %**

Leguminous crops contribute to N fixation and therefore, reduce the amount of fertilizer needed in the following years.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Crop Rotation Changes:

- Maize is a very suitable cereal for chicken feed. Thus, livestock feed imports can be avoided.
- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €€

Crop yields did not change, while operational costs decreased and input costs increased. At the same time, labor costs could be reduced.
The grain legume crops are sold to human consumption to a good price making these crops rather profitable.

Further Information

The farmer participates in a research project aimed at increasing human consumption of plant protein and therefore they cultivate lupine and field beans.

Tillage Management

Magnus Bengtsson **reduced the depth of tillage** from 25-20 cm to 15-20cm for all of his arable crops.

CO_2-eq. Reduction: **-0.7 %**

Reducing tillage helps to reduce fossil fuel consumption.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€€

The farmer's experience shows that crop yields and input costs could be maintained, while operational and labor costs could be reduced.

Agroforestry

During the project, the farm has managed a 600-meter long riparian buffer zone on both sides of a watercourse running.

CO_2-eq. Reduction: 1.5-13.5 t C/ha sequestered annually in soil and hedge biomass
Hedges and trees help to sequester atmospheric carbon into plant biomass and soils. Therefore, they function as a carbon sink.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of hedgerow strips:

- On the farm, strips of flowers along the fields are managed and therefore, together with the hedgerows, increase biodiversity.

Economic Viability: €€€
Crop yields and all associated costs (operational, input and labor costs) were maintained at the same level as the new practice.

Root Cutting Tools for a Reduced Tillage

On a medium heavy clay soil, Magnus Bengtsson has quitted plowing in the autumn in favor of ground cultivation combined with a root cutting tool (CMN couch grass killer). After the cultivation/root cutting, he sows radish to cover the field during the winter, catch nitrogen and let the deep roots help prepare the soil for next spring's crop. In the spring, he uses the cultivator a second time and thereafter sows directly in the soil. Compared to what he did before he saves hours and diesel on the field, and gets a better soil structure.

Magnus Bengtsson believes that he can manage without plowing on his clay soils, but that it will be difficult on the sandy soils, at least every year. On the fields where he quit plowing, he estimates that he reduces yearly costs by approximately 100 euro per hectare, without any effect on the yield income. But this is just the measurable economic benefit of the practice.

The biodiversity strips along with the creek nearby have improved pollination and general conditions for wildlife animals and insects. These provide valuable ecosystem services. When the project was started, this was seen as a waste of land among farmers. However, nowadays this practice is getting more and more popular.

Sötåsen: Practical Education about Biogas

Farm Description

Sötåsen is an agricultural college with an educational farm that is managed entirely organically since 1998. The farm has a significant share of self-produced feed. It also features experimental cultivation of protein crops such as lupine and field bean. Sötåsen has previously been working with training in economical driving, installation of solar panels and other energy-saving technology.

Part of the farm's agricultural college is the gardening students. Together, they experiment with integrating the gardening activities and vegetables with the agricultural crops to increase biodiversity.

Farmer Statement

"This project is fully in line with our long-term environmental work here at Sötåsen. Now we get the chance to take a step further and disseminate knowledge to our students. The exchange with other farms in Sweden, Germany and Italy feels great."

Nutrient Management

On this farm, the animal manure is subjected to anaerobic fermentation to generate and capture methane (CH_4). This is burned in an engine to generate electricity and heat energy to replace fossil fuels. Liquid and solid residues are brought back to agricultural land.

CO_2-eq. Reduction: **- 200 %**

The fermentation of animal manure in a biogas facility helps to reduce methane emissions and produces at the same time electricity and heat.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Biogas Plants:

- Producing own electricity increases the farm's resilience and independence.

Economic Viability: €€€

With the new practice established, crop yields increased, while operational costs decreased. Input and labor costs were maintained.

Crop Rotation Management

The crop rotation consists of three years of ley followed by winter wheat, barley/oats/field beans, and oats which is under-sown with ley. Before the project, no field beans were cultivated.

CO_2-eq. Reduction: **+7 %, mainly due to new drying acitvities**

Legume crops contribute to N fixation and therefore, reduce the amount of fertilizer needed in the following years.

Climate Change Adaptation Benefit: ☒☐

Co-benefits of Legumes:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €€€

Crop yields, operational and labor costs were maintained, while input costs could be reduced with the new practice.

Tillage Management

The farm avoids plowing after grain legumes. Furthermore, basic tillage operations are avoided for grass-clover due to the under-sown clover in oats.

CO_2-eq. Reduction: -10.6 %

Reducing tillage helps to reduce fossil fuel consumption.

Climate Change Adaptation Benefit: ☒☐

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€€

Crop yields, input and labor costs could be maintained at the same level as the new practice. At the same time, operational costs decreased.

Agroforestry

The farm has been installing a 300 m long windbreak hedge. The species selection was based on the somewhat challenging situation with a heavy rodent population. The selected hedge species are amelanchier, aroni, Rosa rugose, Corylus avellana, and Ribes alpinum. To minimize costs bulk plants produced from seed or cuttings was primarily used.

CO_2-eq. Reduction: 0.6-5.4 t C/ha sequestered annually in soils, and hedge biomass

Hedgerows and tree strips lead to C sequestration in above- and belowground biomass and in soil.

Climate Change Adaptation Benefit: ☒☐

Co-benefits of Woody Elements:

- Living habitat for diverse animals (biodiversity protection).

Economic Viability: €€€

Crop yields and all associated costs (input, operational and labor costs) were maintained with the new practice.

Practical Education about Fossil Fuels, Soil Fertility and Organic Farming

On the entire farm, all the machines are run on HVO (hydrated vegetable oil). They also have trials with upgrading the biogas locally to be compatible with the tractors. All animals on the farm are fed with feed which is produced/cropped on the farm. On-farm heat treated field beans improve protein quality which means that external protein concentrate (e.g., soy) is not required for the high yielding cows. The heat treatment makes the protein more stable in the rumen, and more feed protein is directly absorbed in the small intestine.

The farm is integrated with a college, and all is organic which means that the students get a holistic education in organic agriculture and horticulture. This is an important platform creating a knowledge base for tomorrow's organic farmers. On the picture below students discuss together with farmers about the soil structure in the fields where low tillage is compared with regular plowing. This test was part of the **SOLMACC** project. The products from gardening are sold locally and in the school restaurant.

Trägsta: Dairy Production and Animal Welfare

Farm Description

Trägsta gård is located in a northern region of Sweden called Jämtland. It is organic since 2008, and they have 140 milking cows, 260 hectares of arable land and 20 hectares of grazing land. They experiment with several practices to reduce their impact on the climate and to improve overall environmental impacts.

"We have worked hard to make our production more efficient and rationalized. Taking the step to streamline from a climate perspective seems like a natural next step. It is important to spread our experience to others."

Nutrient Management

Manure is subjected to anaerobic fermentation to generate and capture CH_4. This is burned in an engine to generate electricity and heat energy which replace fossil fuels. Liquid and solid residues are brought back to agricultural land and because of a higher percentage of N which is directly absorbable for the crop. This has increased the yields in the ley production.

CO_2-eq. Reduction: **- 85 %**

The fermentation of animal manure in a biogas facility helps to reduce methane emissions and produces at the same time electricity and heat.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Biogas Plants:

- Producing own electricity increases the farm's resilience and independence.

Economic Viability: €€€

The farmer's experience has shown that crop yields increased largely with the new practice (more than 10%), while operational costs decreased. Labor and input costs remained at the same level.

Crop Rotation Management

The farm has worked with optimizing their crop rotation to sync it with the feed management, aiming for as high proportion of roughage as possible. During the project, they switched from hired silage services to invest in their own machine line-up in order to better optimize harvest time and nutrient content.

The farm extended the utilization period of forage legume leys from 4 to 5 years by introducing innovative re-seeding techniques to avoid leys destruction.

CO_2-eq. Reduction: **-21%**

Roughage from grass-clover leys are one of the most climate-friendly crops.

Increased proportion of roughage reduces the requirement for buying concentrate to the milking cows and makes the farm more resilient and climate-friendly.

Legume crops contribute to N fixation and therefore, reduce the amount of fertilizers needed in the following years.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Legumes:

- Enhanced crop biodiversity on the arable fields, supporting a more diverse insect fauna.
- Higher soil fertility because of N fixation of legumes.

Economic Viability: €€€

With the new practice, yields increased largely (more than 10%), while operational costs decreased. Input and labor costs remained at the same level.

Tillage Management

When joining the project, the farm started working with adapting the cultivation depth for plowing depending on field conditions. For most fields, the depth could be reduced from 20-25 to 10-15 cm.

CO_2-eq. Reduction: **-0.6 %**

Reducing tillage helps to reduce fossil fuel consumption.

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Reduced Tillage:

- Potential increase of organic matter in the top soil.
- Helps to reduce soil erosion.
- Increases water holding capacity.

Economic Viability: €€€

While crop yields and input costs could be maintained, operational and labor costs could be reduced with the new practice.

Agroforestry

The farm has a fenced mixed forest/grazing area on 15-20 ha. The area is now grazed by the young cattle, but they also cooperate with a neighboring sheep farmer to create a mixed grazing system. The goal of the silvopastoral system is to enhance grass production in areas which are now being forested while also focusing on the highest economic value on the trees which are left in the field. Pines are to be stem pruned for maximizing timber value while allowing more light to reach the ground. Some spruce is kept and sold as wood pulp. Birches as managed for firewood. Grey alders are kept as nitrogen fixers. Some junipers are saved for wildlife.

CO_2-eq. Reduction: 4-5 t C/ha sequestered annually in the soil

These practices lead to C sequestration in above- and belowground biomass and in the soil. Part of the woody biomass is used for heating and thus replaces fossil fuel (CO_2 mitigation).

Climate Change Adaptation Benefit: ☒☒

Co-benefits of Silvopastures:

- Living habitat for diverse animals (biodiversity protection).
- Diversified income source.

Economic Viability: €€

The farmer's experience has shown that crop yields increased, while operational and input costs could be maintained. At the same time, the labor effort increased largely.

Dairy Cows, Animal Welfare and Climate Change

Good health and a long lifetime of the dairy cows are essential factors for a low carbon footprint of milk. The health of the dairy cows at Trägsta has improved significantly during the last 5 years from an already good standard. This is due to improved management methods and a good strategy involving staff and the whole family. Together, routines concerning cow comfort and animal welfare were improved at the farm. A higher proportion of roughage in the feed ration improves rumination and even the health of the cows. This farm has a management system which is a role model for organic dairy production which should be copied by more farms in the region and across Europe.

Integrate Climate-Friendly & Resilient Agriculture

The SOLMACC project has shown that climate-friendly and resilient farming is possible in the European Union. However, if we want to achieve climate change mitigation goals in line with the recently ratified Paris Agreement, further efforts of all stakeholders are required. This means in particular that the farmers are not left alone with the burden of climate change mitigation and adaptation. It means that farmers are supported financially by policy instruments such as the CAP, but also by consumers that support a climate-friendly and resilient agricultural sector of the EU.

The project has shown that many different options exist to reduce GHG emissions on the farm-levels. They depend on the farm structure, but also on production systems, soil types, climate regions and last, but not least on financial capacities of the farmers. Farmers need to be supported to become aware of win-win situations, where they can decrease GHG emissions, while these measures help them to adapt to inevitable climate change impacts and at the same time increase their commercial revenues to make a decent living. Here, farm advisory services are the key to support a knowledge transfer between scientific understanding of mitigation potentials and farm practices.

The four overarching SOLMACC strategies, to optimize nutrient management, crop rotations, tillage systems, and to start agroforestry practices, are a good starting point for farmers to think about the questions where resources can be optimized, machinery equipment usage reduced or new farming practices implemented on the farm. However, not all of the above measures can be applied by every farmer in the European Union. This requires that farmers are again enabled to look at their farm from the climate perspective and supported to find locally adapted solutions.

The SOLMACC project has shown that mainstreaming climate-friendly farming practices requires role models for other farmers and consumers in a society that needs a quick change towards a sustainable future. The presented demonstration farmers have shown that there is a high motivation to transform the current agricultural practices and test new innovative ones. They have shown that it is possible to move towards a holistic farming system that integrates climate change mitigation and adaptation benefits that help farmers to stabilize or even increase crop yields while protecting our valuable ecosystem services.

We hope with this brochure to enable other farmers to become inspired for a climate-friendly and resilient agriculture systems in line with the EU policy goals. The great work at the participating SOLMACC demonstration farms motivates other farm advisors and farmers to realize the benefits that come along with climate-friendly and resilient farming. Policymakers must recognize the potential of organic farms to help achieve not only climate goals, but also economic benefits that come along. Finally, the consumers have to realize their role in this complex food system, to understand that farmers cannot do it alone, but we as consumers need to support them to overcome difficulties that might be associated with a sustainable production system.

FURTHER READINGS

ENGLISH LITERATURE AND LINKS

VIABLE CLIMATE-FRIENDLY FARMING: SOCIO-ECONOMIC STRATEGIES - http://solmacc.eu/wp-content/uploads/2017/10/SOLMACC_socio-eco_broch_web-2.pdf

Organic Farming, Climate Change Mitigation and Beyond: Reducing the environmental impacts of EU agriculture - http://www.ifoam-eu.org/sites/default/files/ifoameu_advocacy_climate_change_report_2016.pdf

Policy Recommendations: Increasing climate change mitigation and adaptation of the agriculture and food sector - http://solmacc.eu/wp-content/uploads/2018/05/IFOAMEU_SOLMACC_policy-recommendations_FINAL_web_cover_20180518.compressed.pdf

What can organic farming contribute: https://www.rural21.com/english/news/detail/article/what-can-organic-farming-contribute-00002609/

Knowledge platform of farming practices: http://farmknowledge.org/

GERMAN LITERATURE AND LINKS

KLIMAFREUNDLICHE LANDWIRTSCHAFT: SOZIOÖKONOMISCHE STRATEGIEN - http://solmacc.eu/wp-content/uploads/2017/12/607-SOLMACC-DE-web.pdf

Valuable websites concerning climate-friendly agricultural practices:

Bioland leistet aktiven Klimaschutz: https://www.bioland.de/ueber-uns/bioland-themen/klimaschutz.html

Klimawirkungen und Nachhaltigkeit ökologischer und konventioneller Betriebssysteme: http://www.pilotbetriebe.de/download/Thünen_Report_29.pdf

Klimaschutz auf dem Biobetrieb: https://shop.fibl.org/DEde/1552-klimaschutz.html?ref=1

ITALIAN LITERATURE AND LINKS

AGRICOLTURA SOSTENIBILE "CLIMATE FRIENDLY": STRATEGIE SOCIOECONOMICHE - http://solmacc.eu/wp-content/uploads/2017/12/607-SOLMACC-IT-web.pdf

Valuable websites concerning climate-friendly agricultural practices:

https://aiab.it/category/progetti-e-ricerca/

http://www.aiab-aprobio.fvg.it/produttori/bollettini-lotta-guidata/

SWEDISH LITERATURE AND LINKS

MOT ETT KLIMATSMART LANTBRUK: SOCIOEKONOMISKA STRATEGIER - http://solmacc.eu/wp-content/uploads/2017/12/607-SOLMACC-SE-web.pdf

Valuable websites concerning climate-friendly agricultural practices:

www.ekolantbruk.se

www.agroforestry.se

www.ekhagastiftelsen.se

www.greppa.nu

www.slu.se/epok

Are you further interested in this project?
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