Transforming Unsustainable management of soils in key agricultural systems in EU and China
Developing an integrated platform of alternatives to reverse soil degradation

Technical measures for soil degradation control

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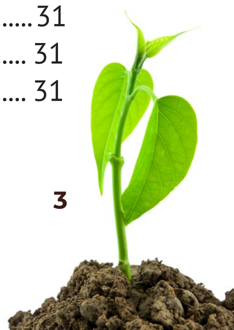
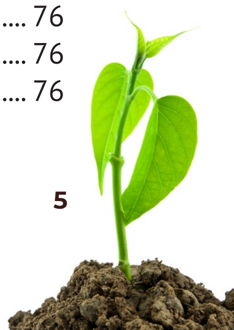




Preface

This catalogue aims to present soil restoration and fertilization strategies with feedback from stakeholders in the EU and China. The catalogue consists of a list of practices that lead to soil degradation processes (Chapter 2). The processes were defined with a multidisciplinary approach by scientists from different fields (soil physics, hydrology, plant and environmental sciences, nutrient management and agronomy). Therefore, they are described in more detail independently of each other in the context of each soil degradation process and their contribution to mitigating or even restoring soil functions.

How to use this material?

- You can use this material either online or offline by downloading it via the DST application or from the website. The catalogue is designed to help users find the most effective strategies for their specific problems and stage of soil degradation identified with DST.
- The catalogue is relatively extensive text material. To make its use as effective as possible, it is organized by links that make it easy to reach the desired section of the document. Each link is marked in the text by a symbol ♦.
- There are six main processes of soil degradation. General information about the soil degradation processes can be found below.
- Here you can select the main degradation process that is relevant for your parcels or has been identified by the DSTs ♦.
- Hyperlinks (text with symbol ♦) will guide you to suitable restoration strategy, you can also obtain further information on financial support in your country.
- The entire document is "nationally oriented", so that users can obtain specific and relevant information for the in their own country.
- For the most efficient use of the catalog, we recommend the simultaneous use of applications for individual soil degradation processes (DSTs). The DSTs are available via these link: https://dev-tudi.web.app/

Soil degradation processes

Soil erosion

The loss of soil leads to a decline in organic matter and nutrient content, the breakdown of soil structure and reduces the available soil water, which can lead to an increased risk of flooding and landslides in neighbouring areas. The nutrient and carbon cycle can be significantly altered by the mobilisation and deposition of soils (Quinton et al. 2010), as eroded soils can lose 75 % - 80 % of their carbon content, leading to a release of carbon into the atmosphere (Webster 2005). Soil erosion has a strong impact on the environment and causes high economic costs. Soil and water protection strategies are needed to mitigate these impacts (Eurostat 2020).

The strategies against soil erosion can have two effects. Firstly, they prevent further degradation of the soil profile and associated off-site effects, allowing the soil to naturally develop. Secondly, in some cases, they can actively help to restore soil properties that are necessary for better soil erosion resistance, but also more generally for better soil functioning.

The first group mostly involves technical measures to shorten slope length, reduce slope gradients or promote water retention by influencing the local topography (buffer strips, ditches and waterways, hedgerows, walls, reservoir tillage or fish scale pits). The second group mainly comprises conservation agriculture techniques (mulching, no-till, reduced tillage, cover crops) and the direct conversion of arable land into permanent crops (grassing, afforestation).

Main strategies to reduce soil erosion and restore soil erosion resistance valid for EU and China are presented in following chapters.

Soil structure

Water storage and water flow in soils depend to a large extent on the soil structure, which strongly determines the pores network. The structural stability, water transmission properties of the soil and the pores connectivity, determine the infiltration capacity of the soil and control runoff (Rajkai et al. 2015, 2018). There is a strong interaction between soil structure and hydrophysical properties their interrelationships are complex and multifactorial and not yet fully understood. Research to describe these relationships and to quantify the effects of soil degradation processes on soil water management is becoming increasingly important and relevant. Soil structure can be characterised as the shape, size and spatial arrangement of individual and differently stable aggregated soil particles.

Soil structural degradation was estimated from bulk density, aggregate stability and available water capacity data measured in soil samples from virgin soils and arable land (Dilkova, 1985; Dilkova et al., 1998; Stoichev et al., 2000). The analysis of these data shows that the increase in bulk density of the topsoil in arable soils is between 1 and 23 %, depending on the soil type. Soil compaction is associated with a corresponding reduction in the aggregate stability of the soil, which is between 40 and 80 %, and the available water capacity, which is between 1 and 29 %. The aggregate stability of more than 60 % of Bulgarian soils can be characterised as good and that of only 3 % as poor. Anthropogenic pollution has led to a deterioration in the aggregate stability of agricultural soils, which is predominantly poor (Dilkova et al. 1998). Irrigation can also have an influence on soil structure and hydraulic properties. As a result of long-term irrigation experiments on selected soil properties, it was found that the timing of irrigation influenced bulk density and saturated hydraulic conductivity, while organic matter and total nitrogen decreased (Bakacsi et al. 2009).

Intense rainfall in spring and summer, followed by long dry periods, is the most common cause of crusting of structurally damaged soils. Surface crusting has a direct and indirect effect on soil properties. The direct effects are related to the inhibition of seed emergence, root and plant growth. Indirect effects include a reduction in the soil permeability, which increases both the risk of soil erosion and the soil penetration resistance. Soil crusting is a widely recognised agronomic problem in the region of the Distric Planosols (Stoichev et al. 2000).

Soil compaction

The pressure on the soil surface causes a break-up of the aggregated soil structural units, a realignment of the soil particles and an increase in bulk density (Cassel et al. 1983).). The higher bulk density and the lower porosity, water holding capacity and infiltration rate impair plant development compared to non-compacted soils (Al-Kaisi a Kwaw-Mensah 2017).

Healthy soils have a soil structure that is resilient to soil compaction, provided that management is done with soil conserving techniques and under dry soil conditions. Accordingly, conservation agriculture systems are preferable to conventional intensive tillage systems, mono-cropping systems, overgrazing, the removal of crop residues, and careless field traffic. Thus, soil protection and restoration strategies affect all areas of agricultural management, including soil/tillage management, plant diversity, cover crops and residue management, manure application, and field traffic control (Al-Kaisi a Kwaw-Mensah 2017).

Soil organic carbon

Soil organic carbon, as part of soil organic matter (SOM), is a fundamental component and indicator of soil fertility (Christensen and Johnston 1997; Reeves 1997 It is known to promote soil aggregation, stabilize soil structure, increase nutrient availability and improve water holding capacity (Dhaliwal et al. 2019). In addition, it supports soil biodiversity (Prescott a Grayston 2023) immobilises toxic organic pollutants, sequesters carbon (Paul 2016), and supports ecosystem functions related to carbon and nitrogen cycling (Hoffland et al. 2020) as well as freshwater and groundwater quality (Lal 1998).

A general decline in SOM has been recorded across European soils (Toth et al. 2008). Land use and land use change have been one of the main drivers of SOC changes in Europe, but climate also plays an important role, mainly the mean annual temperature and its seasonality (De Rosa et al. 2024)

Biota activity

Biological degradation of the soil refers to the reduction in the number and species of soil fauna and flora. This can be linked to the reduction of vegetation cover and biomass, changes in vegetation diversity due to changes in habitat composition. The use of mineral fertilizers, chemicals for weed, pest and disease control all have a negative effect on soil micro- and macro-organisms. Also, physical disturbances such as soil erosion, sealing, compaction etc., reduce the number and composition of soil taxa. Besides soil physical and chemical properties water availability and temperature also affect the abundance and functioning of soil biota.

Nutrient balance

A correct balance of nutrients in the soil is necessary to maintain life and plant production. A nutrient imbalance, on the other hand, is when one or more essential nutrients are either deficient or in excess compared to the needs of the plants at a given time. A nutrient deficiency can lead to yield and quality losses, while an excess can damage the environment through losses from the soil system. The intensification of fertilisation in recent decades with the aim of increasing yields has led to relevant environmental problems for air, water and soil (C. Lu a Tian 2017; Peñuelas et al. 2013).

A variety of new or updated practices have been proposed to reduce the amount of fertilisers applied and improve agricultural system sustainability, defined as the ability to produce without soil degradation and environmental impacts (Penuelas et al. 2023). Among these, the comparison of crop requirements with additions through a simple mass balance remains the simplest and cheapest method.

List of soil restoration strategies

Table 1 describes the agricultural practices and measures used to combat soil degradation. The impact of each practice/measure to improve soil quality is linked to each of the soil degradation processes identified as particularly relevant for the EU and China (link to D2.1). The principles of the measures and practices are described in Overview of soil restoration strategies.

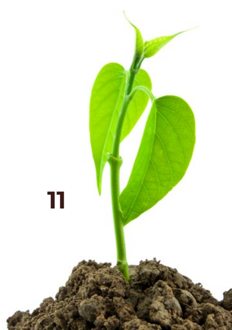


Table 1. List of applicable practices and their relevance for the restoration of soil functioning in each of the associated degradation processes.

Measure/strategy	Effect related to climate change – drought*	Effect related to climate change – flash floods*	Degradation process/degraded features					
			Soil erosion	Soil structure	Soil compaction	S. organic carbon	Biota activity	Nutrient balance
Non inversion tillage	○	○	+	+	+	-	+	-
No-till	○	○	+	+	+/-	-	+	-
Strip-till	•	•	+	+	(+)	-	+	-
Cover crops	•	•	+	+	+	+	+	+
Crop residue incorporation	○	○	+	+	+	+	+	+
Mulching	•	•	+	+	(+)	+	+	+
Grassing	•	•	+	+	(+)	+	+	+
Strip cropping	•	•	+	(+)	(+)	-	+	-
Contour farming	○	○	+	(+)	(+)	-	+	-
Sustainable crop rotation	○	○	+	+	(+)	+	+	+
Vegetated buffer strips	•	•	+	+	(+)	-	+	-
Hedgerows	•	•	+	+	(+)	-	+	-
Reservoir tillage	••	••	+	-	(+)	-	(+)	-
Retention ditches	••	••	+	-	-	-	(+)	-
Drainage ditches	••	••	+	-	(+)	-	-	-
Fish scale pits	•	•	+	-	(+)	-	(+)	-
Terracing	•	○	+	-	-	-	(+)	-
Sustainable irrigation	•	○	(+)	+	(+)	(+)	+	(+)
Organic fertilization	•	•	(+)	+	+	+	+	+
Planning traffic frequency	○	○	-	+	+	-	(+)	-
Heavy traffic control	○	○	-	-	+	-	(+)	-
Grazing management	○	○	(+)	+	+	+	+	+
Green manure	•	•	(+)	(+)	+	+	+	+
Agroforestry	•	○	+	(+)	(+)	+	+	+
Nutrient management plan	○	○	-	-	(+)	+	+	+
Precision fertilisation	○	○	-	-	(+)	-	+	+
Regenerative agriculture	•	•	(+)	-	+	+	+	+

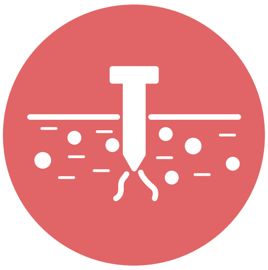
*○ *no effect*• *slight effect* •• *important effect*

Soil degradation process selection

Based on individual knowledge of situation

Soil erosion

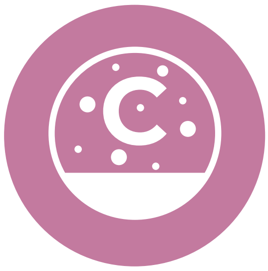
Nutrient balance



Soil compaction

Biota activity

Soil structure



Soil organic carbon

CLICK FOR THE LIST OF RELEVANT RESTORATION STRATEGIES.

Based on DST results (recommended)

For the most efficient use of the catalogue, we recommend the simultaneous use of applications for individual soil degradation processes (DSTs). The DSTs are available on these link: https://dev-tudi.web.app/

First, you select a suitable DST (based on an individual assessment of the actual situation at your location). These tools will guide you through the process of assessing your situation and provide you with information about the severity of the selected problem at your site.

This section collects detailed information on individual strategies for soil restoration and conservation and links them to national funding opportunities.

The first table is a crosswalk linked to each relevant section.

Selected (DST)	Result from DST	List of suitable measures
	OK – Warning – Danger	Soil erosion
	OK – Warning – Danger	Soil structure
	OK – Warning – Danger	Soil compaction
	OK – Warning – Danger	Soil organic carbon
	OK – Warning – Danger	Biota activity
	OK – Warning – Danger	Nutrient balance

BACK TO SOIL DEGRADATION PROCESS SELECTION

Soil erosion

Suitable restoration strategy	Suitable for DST result (traffic lights)	Financial support
Non inversion tillage	🟠	🇦🇹 🇨🇿 🇭🇺 🇮🇹 🇪🇸 🇬🇧
No-till	🔴	🇦🇹 🇨🇿 🇨🇳 🇮🇹 🇪🇸 🇬🇧
Strip-till	🟠	🇦🇹 🇨🇿 🇨🇳 🇮🇹 🇬🇧
Cover crops	🟠	🇦🇹 🇧🇬 🇨🇿 🇨🇳 🇭🇺 🇮🇹 🇪🇸 🇬🇧
Crop residue incorporation	🟠	🇨🇿 🇨🇳 🇪🇸 🇬🇧
Mulching	🟠	🇦🇹 🇨🇿 🇨🇳 🇭🇺
Grassing	🔴	🇨🇿 🇨🇳 🇮🇹 🇬🇧
Strip cropping	🟠	🇨🇿 🇨🇳 🇬🇧
Contour farming	🟠	🇧🇬 🇨🇿 🇨🇳
Sustainable crop rotation	🟠	🇧🇬 🇨🇿 🇨🇳 🇮🇹 🇪🇸 🇬🇧
Vegetated buffer strips	🟠	🇦🇹 🇧🇬 🇨🇿 🇨🇳 🇮🇹 🇪🇸 🇬🇧
Hedgerows	🔴	🇦🇹 🇧🇬 🇨🇿 🇨🇳 🇮🇹 🇪🇸 🇬🇧
Reservoir tillage	🔴	🇨🇿 🇨🇳
Retention ditches	🔴	🇨🇿 🇨🇳 🇬🇧
Drainage ditches	🔴	🇨🇿 🇨🇳 🇬🇧
Fish scale pits	🔴	🇨🇳 🇬🇧
Terracing	🔴	🇧🇬 🇨🇿 🇨🇳 🇬🇧
Planning traffic frequency	🟠	🇨🇿 🇨🇳 🇬🇧
Green manure	🟠	🇧🇬 🇨🇿 🇨🇳 🇮🇹 🇬🇧
Agroforestry	🟠	🇧🇬 🇨🇿 🇨🇳 🇮🇹 🇪🇸 🇬🇧
Nutrient management plan	🟠	🇨🇿 🇨🇳 🇮🇹 🇬🇧
Precision fertilisation	🟠	🇨🇿 🇨🇳 🇮🇹 🇪🇸 🇬🇧
Regenerative agriculture	🟠	🇧🇬 🇨🇳 🇭🇺

BACK TO SOIL DEGRADATION PROCESS SELECTION

Soil structure

Suitable restoration strategy	Suitable for DST result (traffic lights)	Financial support
Non inversion tillage		
No-till		
Strip-till		
Cover crops		
Crop residue incorporation		
Mulching		
Grassing		
Strip cropping		
Sustainable crop rotation		
Vegetated buffer strips		
Hedgerows		
Sustainable irrigation		
Organic fertilization		
Planning traffic frequency		
Heavy traffic control		
Green manure		
Agroforestry		
Nutrient management plan		
Precision fertilisation		
Regenerative agriculture		

BACK TO SOIL DEGRADATION PROCESS SELECTION

Soil compaction

Suitable restoration strategy	Suitable for DST result (traffic lights)	Financial support
Cover crops		
Mulching		
Crop residue incorporation		
Sustainable crop rotation		
Organic fertilization		
Planning traffic frequency		
Heavy traffic control		
Grazing management		
Green manure		
Agroforestry		
Regenerative agriculture		

BACK TO SOIL DEGRADATION PROCESS SELECTION

Soil organic carbon

Suitable restoration strategy	Suitable for DST result (traffic lights)	Financial support
Cover crops	Orange	Austria, Bulgaria, Czech Republic, China, Hungary, Italy, Spain, United Kingdom
Crop residue incorporation	Orange	Austria, Czech Republic, China, Spain, United Kingdom
Mulching	Orange	Austria, Czech Republic, China, Hungary
Grassing	Red	Czech Republic, China, Italy, United Kingdom
Sustainable crop rotation	Orange	Bulgaria, Czech Republic, China, Italy, Spain, United Kingdom
Vegetated buffer strips	Orange	Austria, Czech Republic, China, Italy, Spain, United Kingdom
Hedgerows	Orange	Austria, Bulgaria, Czech Republic, China, Italy, Spain, United Kingdom
Organic fertilization	Orange	Bulgaria, Czech Republic, China
Green manure	Orange	Bulgaria, Czech Republic, China, Italy, United Kingdom
Nutrient management plan	Orange	Czech Republic, China, Italy, United Kingdom
Precision fertilisation	Orange	Czech Republic, China, Italy, Spain, United Kingdom
Regenerative agriculture	Orange	Bulgaria, China, Hungary

BACK TO SOIL DEGRADATION PROCESS SELECTION

Biota activity

Suitable restoration strategy	Suitable for DST result (traffic lights)	Financial support
Non inversion tillage		
No-till		
Strip-till		
Cover crops		
Crop residue incorporation		
Mulching		
Grassing		
Strip cropping		
Sustainable crop rotation		
Vegetated buffer strips		
Hedgerows		
Sustainable irrigation		
Organic fertilization		
Green manure		
Agroforestry		
Nutrient management plan		
Precision fertilisation		
Regenerative agriculture		

BACK TO SOIL DEGRADATION PROCESS SELECTION

Nutrient balance

Suitable restoration strategy	Suitable for DST result (traffic lights)	Financial support
Cover crops		
Crop residue incorporation		
Mulching		
Grassing		
Strip cropping		
Sustainable crop rotation		
Vegetated buffer strips		
Hedgerows		
Organic fertilization		
Planning traffic frequency		
Grazing management		
Green manure		
Agroforestry		
Nutrient management plan		
Precision fertilisation		
Regenerative agriculture		

BACK TO SOIL DEGRADATION PROCESS SELECTION

Overview of soil restoration strategies

Non inversion tillage

Description

Non-inversion tillage systems loosen the soil without using a plough and thus without inversion of the soil. The non-inversion has several positive effects on soil life, which promotes good soil structure, increased water retention, and thus soil fertility. With non-inversion tillage reducing mechanical soil disturbance in seedbed preparation, a better soil physical environment is maintained (e.g., mechanical impedance and aeration), improving root growth and root functions, leading also to positive effects in crop yield (Cannell 1985).

Implementation

Non inversion tillage systems can be applied in most agricultural systems without major restrictions. The cultivator can be used both for primary and secondary tillage operations, causing no soil inversion and thus minimising unproductive water loss and disturbance of soil structure and soil life habitat.

How does the strategy work in relation to the given threat?

Soil erosion

Non-inversion treatment involves measures and progresses promoting better soil condition, more stable soil aggregates and a higher organic matter content in the soil. The soil becomes more resistant to raindrops and surface runoff. This can lead to a reduction in the intensity of soil erosion on plots where non-inversion tillage is used compared to plots with conventional tillage.

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

Reduced tillage promotes the biological activity of the soil by reducing soil disturbance and preserving soil structure. It prevents soil erosion and improves moisture retention as well as retaining organic residues, creating a favorable environment for soil microorganisms. The remaining crop residues serve as a source of nutrients and promotes the growth of beneficial bacteria and fungi. This increased microbial activity helps improve nutrient cycling, soil structure and overall ecosystem resilience. Reduction in tillage will create conditions favourable for fungi over bacteria as primary decomposers and the arbuscular mycorrhizal fungi (AMF) density and species richness also increases by reduced tillage. Soil ecosystem engineers like earthworms and termites are also benefit from reduced tillage by preventing the bodies, burrows and nests to be destroyed.

Figure 1. Wing share cultivator "Synkro 2600" by Pöttinger. Non inversion tillage does not mix soil layers keeping the original layering.

Soil compaction

Non inversion tillage comprises several measures to alleviate soil compaction compared to conventional tillage practices. The omission of soil inversion benefits soil life and thus improves humus accumulation and improving soil structure. The creation of tillage pans is reduced or prevented and other compacted soil layers (e.g., hard pans, clay pans, and other impenetrable barriers) can still be broken up with tillage operation. Together with soil conservation measures (e.g., cover crops with strong and deep root systems, low-intense management with direct drilling) and good soil management (no management under wet soil conditions) non inversion tillage maintains soil structure and soil life in a healthy state.

Soil structure

Long-term experiments show that soil under minimum or reduced tillage treatment contains more organic matter in the surface layer than in the conventional system, which supports favorable soil structure. The aggregate stability and the total content of the water-stable aggregates are also higher in reduced tillage (Malecka et al. 2012; Šimanský et al. 2016).

Soil organic carbon content

No significant positive impact. Although some papers reported an increase in SOM content after the conversion from plowing to non-inversion tillage, most of researchers now agree that SOC under non-inversion tillage is only distributed differently along the soil profile, also depending on the tillage depth.

Implementation challenges

Non inversion tillage systems can be applied in most agricultural systems, including arable land and orchards. They can be operated in a wide range of soil types (from heavy to sandy and abrasive soil types) and moisture conditions (dry land and wet land/irrigation farming). In some cases, non inversion tillage management showed to be more challenging regarding weed control compared to conventional tillage. The spectrum of weeds may shift from broad-leaved weeds to grass weed species, which are typical in shallow non-inversion tillage systems.

Necessary equipment and resources

Non inversion tillage cultivation is usually based on the use of tine and disc implements that do not invert the soil. The tines lift and shatter the soil removing any shallow compaction layers. Subsequently, the discs then cut and mix the straw residue and any soil clods to leave a fine tilth. It is usual for press wheels to be fitted at the rear of the cultivator that firm and level the surface prior to drilling (Morris et al. 2010).

Pros and cons of the strategy

The benefits of non inversion tillage compared to conventional tillage using plows are wide-ranging. Tillage without soil inversion using narrow upright tines reduces moisture loss and energy consumption by the tractor. The present root and soil life systems are less impaired, causing better soil structure, infiltration and water wolding capacity and humus formation.

Compared to conventional tillage, non inversion tillage has hardly any disadvantages. However, being promoted as a conservation tillage system, it must not be disregarded, that depending on local conditions erosion can still be a major concern. Thus, the threat of water erosion should not be underestimated (Öttl et al. 2022).

Additional resources

Paxton Co

BACK TO SOIL DEGRADATION PROCESS SELECTION

No-till
(zero tillage, direct drilling)

Description

The idea behind the no-till technique is to eliminate mechanical tillage of the soil. With no-till, the topsoil is disturbed as little as possible, with the seed being sown directly into the residue of the previous crop (with mechanical opening and closing of the seed slot) or even into a cover crop. This allows the natural development of soil biota and pedogenic processes. Soil conservation is best achieved by using plants with active photosynthesis, crop diversification and maintaining the cover provided by the previous crops.

Implementation

Implementing the no-till practice requires different equipment and skills. Special seeding machines with no-till technology are used to plant stands directly in unprocessed soil, intercrops, but also in a prepared field. Among its main benefits are versatility, saving time, costs and limiting CO_2 emissions into the air. The machines are manufactured in widths of 3 - 8 meters. Wider machines are based on the pneumatic principle. Also significant is the reduction in the number of overpasses, which results in less soil compaction. In general, less soil disturbance ensures greater resistance to wind and water erosion.

Figure 2. Soil conserving no-tillage technique at soybean field in Raasdorf, Austria (Gunther Liebhard).

How does the strategy work in relation to the given threat?

Soil erosion

No-till reduces soil erosion by leaving crop residues or even whole plants on the field surface, which act as a protective layer against wind and water erosion. The crop residues or leaves prevent water droplets from falling directly onto the soil surface and thus limit the breaking up of the soil aggregates by the kinetic energy of the raindrops. This significantly limits the initial phase of the erosion process and reduces the erosion load on the soil by up to 90% compared to conventional tillage systems. In addition, the soil structure is preserved, water run-off is reduced and water absorption is improved, preventing the loss of surface water. The promotion of soil microorganisms and the preservation of organic matter contribute to improved soil health and stability. No-till promotes sustainable agriculture by providing long-term erosion control and supporting the overall health of the soil ecosystem.

Fertilizers / nutrient balance

No significant positive impact. However, if fertilisers are not incorporated into the soil, higher losses can be expected as N volatilisation and P erosion. Therefore, the nutrient use efficiency can be reduced.

Biological activity

No-till promotes the biological activity of the soil by retaining organic residues on the surface, creating a favorable environment for soil microorganisms. The absence of tillage helps to maintain a diverse microbial community and improve soil health. The remaining crop residues serve as a source of nutrients and promotes the growth of beneficial bacteria and fungi. This increased microbial activity helps improve nutrient cycling, soil structure and overall ecosystem resilience. No-till creates conditions favourable for fungi over bacteria as primary decomposers. The arbuscular mycorrhizal fungi (AMF) density and species richness also increases by no-till. Soil ecosystem engineers like earthworms and termites are also benefit from no-till by preventing the bodies, burrows and nests to be destroyed.

Soil compaction

No-tillage management may have various effects on the soil structure regarding compaction. On the one hand, the missing mechanical loosening may lead to increased compaction, particularly on soils that are susceptible to compaction and that are not ideally managed (e.g., exhausted carbonates or management under wet soil conditions). On the other hand, no-till reduces soil compaction by avoiding the disruptive effects of traditional ploughing. By avoiding tillage, the soil structure remains undisturbed, allowing the development and maintenance of well-defined soil pores. This preservation of the natural soil structure improves water infiltration and root penetration and minimizes the risk of compaction. In addition, the crop residues in no-till systems help to cushion the soil and prevent compaction that can be caused by heavy machinery and agricultural activities. Soil compaction can

effectively be prevented together with accompanying soil conservation measures (e.g., cover crops with strong and deep root systems). It should be kept in mind, that a transformation from conventional tillage to no-tillage may lead to problematic compaction for the first years after transformation until resilience of the soil has increased and the positive effects overweigh.

Soil structure

No-till promotes a stable soil structure by preserving the natural arrangement of soil particles and aggregates. The absence of tillage prevents the destruction of the soil structure and maintains well-defined pores and channels, therefore in the vegetation period, the water content of the soil is also higher in long-term no-till treatment compared to conventional. Crop residues contribute to organic matter and promote the development of stable soil aggregates. This improved structure enhances water infiltration, root penetration and resistance to erosion. Over time, the cumulative effects of no-till result in a more resilient and stable soil structure. No-till can be particularly effective in retaining soil moisture, as undisturbed soil retains its structure and organic matter content, which can improve soil water holding capacity and reduce evaporation. The water drop penetration time (WDPT) is longer (slow wetting) in the case of no-till, than conventional ploughing, resulting in more balanced water availability for crops (Füleki-veress et al. 2023; Gelybó et al. 2022; Šimanský et al. 2016).

Soil organic carbon content

No-till does not improves the organic carbon content of the soil, but it allows a different distribution of organic matter along the profile. In particular, organic matter is concentrated at the soil surface, as the crop residues and organic fertilisers remain on the surface and serve as a source of organic matter. The lack of tillage prevents the rapid decomposition of organic matter, allowing it to accumulate in the soil. This build-up of organic carbon in the surface layers improves soil structure, water retention and nutrient availability in the shallow part of the soil. Consequently, most of soil life is concentrated in the first centimetres, including. In addition, the promotion of microbial activity in the soil during no-tilland soil fauna, whose activity contributes to the incorporation of organic carbon into the soil matrix.

Implementation challenges

This management practice can be carried out independently or in a self-reliant manner.

No-till farming requires some different skills than conventional farming. A combination of technology, equipment, pesticides, crop rotation, fertilization and irrigation must be adapted to local conditions. Successful application depends crucially on the soil type, soil structure, soil moisture and the type and current stage of development of the crops.

In order for the target crop to be successfully grown, catch or cover crops must be killed. This practice depends very much on the freezing of the previous crop or its mechanical destruction or the application of total herbicides. In the first 5 years or so after conversion, yield losses of up to 10% must be expected, which then gradually increase to the original production level. Around 7 years after the start of implementation, the yield usually increases by around 5 % above the original level.

Necessary equipment and resources

The specific equipment needed can vary based on the scale of the operation, the type of crops grown, and local soil conditions.

- specialized seeding equipment such as heavier seed drills
- in no-till farming, more herbicides are often used than in conventional tillage to kill cover crops, weeds or volunteer crops, although winter cover crops, soil solarization or burning can serve as alternatives.
- depending on the C/N ratio of the crop and the local conditions, a higher quantity of fertilizer must be applied

Pros and cons of the strategy

PROS:

- significant cost savings on fertilizers
- significant economic benefits due to savings in working time and fuel
- significantly smaller tractor, faster movement and lower tractive force required
- synergy effects for most threats to soil degradation (i.e. soil erosion, soil biota, organic carbon, soil compaction)

CONS:

- initial reduction in crop yields after initial implementation of strategy
- additional farmer education/training required
- potential difficulties with weed and pest control or death of cover crops before sowing

Additional resources

Food and Agricultural Organisation of the UN (FAO), Main principles of conservation agriculture: https://www.fao.org/conservation-agriculture/en/

FAO equipment and manufacturers database: https://www.fao.org/sustainable-agricultural-mechanization/database/en/

Economic motivation for no-till farming: https://www.usda.gov/media/blog/2017/11/30/saving-money-time-and-soil-economics-no-till-farming

Huggins DR., Reganold JP. No-Till: The quiet revolution https://www.ars.usda.gov/ARSUserFiles/20902500/DavidHuggins/NoTill.pdf

BACK TO SOIL DEGRADATION PROCESS SELECTION

Strip-till

Description

Strip tillage refers to a practice of tilling a narrow strip (5 to 20 cm in width) ahead of the drill openers so the seed is sown into a strip of tilled soil, but the soil between the planted rows remains undisturbed and covered with crop residues. It also refers to the general tilling of much wider strips of land on the contour, separated by wide fallowed strips, as an erosion control measure based on tillage. This practice causes more soil disturbance and provides less cover along the rows than no-till.

Implementation

Implementing the strip-tillage practice requires different equipment and skills. A combination of technology, equipment, pesticides, crop rotation, fertilization, and irrigation must be adapted to local conditions. Successful application depends on the soil type, soil structure, soil, and micro-topographical conditions. Colter blades cut through the soil and residue ahead of the tillage shank. Row cleaner removes residue from the front of the tillage shank and berm-building disks, leaving a clean, tilled strip. They usually are mounted behind the cutting coulter and a few inches ahead of the tillage shank. The tillage shank penetrates and loosens soil and is typically designed with a fertilizer injection tube to allow the application of gaseous, liquid, or dry granular fertilizer during the strip-till operation. Tillage depth depends on the soil type, conditions, and the main crop to be planted. Berm-building disks are mounted on each side and behind the tillage shanks. The disks can be mounted to mound the strip to promote moisture runoff and facilitate soil drying in the spring. Conditioning baskets are mounted behind each shank to break soil clods and smooth the surface.

Figure 3. An eight-row strip-till implement being demonstrated at the 2011 conference of the KwaZulu-Natal No-till Club. At Drakensville, South Africa (Alandmanson, 2011).

How does the strategy work in relation to the given threat?

Soil erosion

Strip till contributes to soil erosion control mainly through crop residues, which protect the soil surface, prevent evaporation and thus improve the overall condition of the soil, increase retention and prevent surface runoff.

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

Strip- till promotes the biological activity of the soil by reducing soil disturbance and preserving soil structure. It prevents soil erosion and improves moisture retention as well as retaining organic residues, creating favourable environment for soil microorganisms. The remaining crop residues serve as a source of nutrients and promotes the growth of beneficial bacteria and fungi. This increased microbial activity helps improve nutrient cycling, soil structure and overall ecosystem resilience. It creates conditions favourable for fungi over bacteria as primary decomposers and the arbuscular mycorrhizal fungi (AMF) density and species richness also increases by the reduction of tillage intensity. Earthworms and termites are also benefit from strip-tillage by decreasing the number of bodies, burrows and nests to be destroyed.

Soil compaction

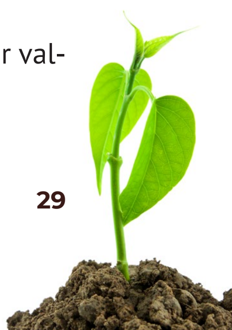
The strip-tillage technique has no particular effect on the compaction status of the soil. However, all positive effects of erosion control and soil structure improvement ultimately also protect against harmful soil compaction.

Soil structure

Strip-till cultivates the future seed furrow only, taking advantage of the benefits of conventional tillage, while the inter-row shows the advantages of direct seeding: preserving a layer of undisturbed soil and soil cover of residues, and maintaining soil structure. Compared to ploughing and no-tillage, in a mid-term (5 years) strip-tillage experiment, the organic carbon, available forms of macro elements, water-stable soil aggregates, total bacteria, total fungi and earthworms increased in the topsoil layer (Fernández et al. 2015; Jaskulska 2019).

Soil organic carbon content

No significant positive impact. However, this technique will create a stratification of SOM with higher values in the shallow soil layers, as crop residues are not incorporated into the soil.



Implementation challenges

Weed suppression on strip-tilled lands can be difficult. In place of cultivation, farmers can suppress weeds by managing a cover crop, mowing, crimping, or herbicide application. However, finding an appropriate cover crop mic for adequate weed suppression may be difficult. Besides, some farmers may be able to strip once there is an early freeze. Lastly, strip-till systems require a high-horsepower tractor; the energy requirement is less than conventional tillage practices.

Necessary equipment and resources

The specific equipment needed can vary based on the soil type, main crop – and cover crop, as well as soil - and micro-topographical conditions. But usually, the necessary equipment and resources are:

- Coulter blades
- Row cleaners
- Tillage shank
- Berm-building disks
- Conditioning baskets

Pros and cons of the strategy

PROS:

- Erosion control
- Conserves soil moisture
- Allows soil warming in the rows.
- Allows in row incorporation.
- Reduced fuel and laboratory costs (compared to conventional tillage practices)

CONS:

- Dependence on herbicides
- Farmers still break the soil's crust which can allow aerobic conditions to speed the decay of organic matter.
- Strip-till requires new equipment, what increases costs.
- High-horsepower tractor

Additional resources

NDSU – North Dakota State University – Strip Till for Field Production https://www.ag.ndsu.edu/publications/crops/strip-till-for-field-crop-production

Eurostat – Statistics Explained: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Conservational_tillage

Food and Agriculture Organization of the United Nations (FAO). https://www.fao.org/3/t1696e/t1696e09.htm

Godsey, C., Kochenower, R., Taylor, R. 2017. Strip-till considerations in Oklahoma. https://extension.okstate.edu/fact-sheets/strip-till-considerations-in-oklahoma.html?Forwarded=pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-5035/PSS-2134web.pdf

BACK TO SOIL DEGRADATION PROCESS SELECTION

Cover crops

Description

Cover crops are any crops grown to cover the soil and may be incorporated into the soil later for enrichment, a practice that is called green manuring . Planting cover crops is beneficial for controlling erosion, suppressing weeds, reducing soil compaction, increasing soil moisture and nutrient content, improving yield potential, attracting pollinators, and providing habitat for beneficial insects, wildlife, and animal food.

Implementation

The implementation of the cover crops depends on the selected species. Cover crops are mainly grouped by the selected plant species, such as legumes, non-legumes, and various combinations of grass-legumes-non-legumes cover crops. Legume cover crops (such as red clover, or vetch) can fix a lot of nitrogen (N), prevent erosion, support beneficial insects, but they are not very good at scavenging nitrogen that is left over the main crops. Non-legume cover crops (such as rye, mustard, and buckwheat) are most useful for scavenging nutrients, providing erosion control, suppressing weeds and producing large amount of residue that adds soil organic matter, although they do not fix nitrogen. The N-fixing ability is important when the cover crop is fully or partially incorporated into the soil, as this is a net supply of N to the soil. Cover crops mixtures offer the best of both categories by combining the benefits of grasses and legumes. However, mixtures often cost more, can create too much residue, and require more complex management. Other cover crop species, such as mustard, are used to reduce attacks by nematodes due to their biocide effect.

Another classification of cover crops is based on the growing period. A first group includes cover crops that are sown in autumn before a spring-sown crop. However, in some environments where winter cereals are harvested soon, such as in southern Europe, summer cover crops can be sown in early July until sowing of the following maize crop. Summer cover crops generally need irrigation. A traditional practice that is being promoted again in southern Europe is the intercropping of white clover in the interrow of wheat, to provide a well-established and fast-growing forage legume at wheat harvest.

Figure 4. Cover crops in woody crops (Spain) (photo: Gema Guzmán).

Cover crops in woody crops, such as olive groves and vineyards, are agricultural practices involving the management of herbaceous vegetation, either sowed or spontaneous, between the tree rows. These covers are used temporarily in arid and semi-arid environments, primarily to control soil erosion caused by surface runoff during the rainy season. They are established in the fall and removed between late spring and early summer to prevent competition for water with the main woody crop. In addition to soil protection, cover crops offer other benefits such as reducing soil compaction and providing habitat for beneficial insects. Their composition can vary depending on the desired benefits, ranging from spontaneous covers with diverse species to sowing annual agronomic species or flower mixes to enhance pollinators.

How does the strategy work in relation to the given threat?

Soil erosion

Cover crops help protect the soil from erosion primarily by protecting the soil surface, preventing evaporation and thereby improving the overall condition of the soil, increasing retention and preventing surface runoff. When the plants are also incorporated into the soil, the organic matter content of the soil increases, which improves soil conditions. The soil becomes more resistant to erosion.

Fertilizers / nutrient balance

Cover crops can act on the nutrient balance in two ways: i) a net addition of N can be provided when the cover crop is a N-fixing legume; ii) a mobilisation of nutrients can be performed, for instance P can be converted from inorganic to an organic but easily-mineralisable form that normally increased the availability of this element to subsequent crops. In addition, if cover crops reduce losses (in particular N leaching and p runoff), this could be regarded as a hidden nutrient supply.

Biological activity

Cover crops play a particularly important role in restoring degraded agricultural soils. Applying cover crops into the soil management system contributes to most of the principal themes of the soil health foundation; 1, covering the soil surface, 2, keeping living roots in the soil, 3, building diversity, 4, minimizing soil disturbance. The impacts of cover cropping on soil biota can have direct and indirect effects. Cover cropping increases the spatial and temporal plant diversity resulting in increased diversity of residues and root systems thereby supporting a wider diversity of soil biota. Cover crops improve the physical structure of the soil which supports the development of microhabitats for soil biomes. The use of cover crops increase the time of vegetation present in the soil which contributes to increased rhizosphere processes providing an increased amount of carbon and nitrogen input that microorganisms can access for nutrients. Cover crops stimulating the microbial abundance of the soil by increasing the organic matter and nutrient content and conserve moisture.

Soil compaction

Cover crops are a fundamental part of any conservation tillage strategy and therefore also fundamental for the prevention and alleviation of harmful soil compaction. Above ground biomass and roots provide nutrition to soil life organisms which provide good soil structure, roots also loosen the soil during growth. Furthermore, even dead cover material protects the soil from erosion and serves as food for soil life organisms.

Soil structure

Cover crop application may improve soil organic matter content, total N-content, and hydraulic properties to facilitate increased water infiltration and storage, contributing to soil structure amelioration in arable soils. It may reduce soil bulk density, mostly in the topsoil layer (Gentsch et al. 2024; Koudahe et al. 2022; Wilson et al. 1982).

Soil organic carbon content

Cover crops that are incorporated into the soil provide a source of organic matter that does not contribute much to the increase of SOM stock, due to the fact that plant tissues are fresh and easy to mineralise. Nevertheless, in situations where most of the soil stable carbon comes from microbial debris, the stimulation of soil microbial life through the incorporation of fresh matter will end up in a slow but relevant increase in SOM content.

Implementation challenges

Utilizing cover crops successfully in agriculture is site-specific and requires special precautions. The applied cover crop species, seeding dates, seeding depths, fertility requirements, and planting methods must be compatible with appropriate local criteria and soil/site conditions. The selected species must be compatible with other elements of the cropping system. Cover crops might be established between successive production crops or companion-planted crops. It needs to be ensured that the selected species and planting dates will not compete with the production crop yield or harvest. Another characteristic that should be taken into account when selecting a cover crop is the resistance to cold temperatures. Winter-killed cover crops will not need an herbicide distribution before the next crop is sown.

A critical aspect of cover crop utilisation is the increased water requirement of the system, that can even prejudice the growth of the main crop in dry years.

Necessary equipment and resources

The specific equipment needed can vary based on the local soil conditions, and topography.

- Specialized mulch seed drills for seeding (autumn).
- Cultivator to incorporate the applied mulch plants with the soil surface (spring).

Pros and cons of the strategy

PROS:

- Shield the soil during fallow periods, between harvest and planting of commercial crops, utilizing the residual soil moisture.
- Reduce soil erosion from wind and water.
- Minimize soil compaction.
- Enhance soil structure and break compacted layers and hard pans.
- Permit a rotation in a monoculture.
- Control weeds and pests with paying attention to the planting time and applied cover crop species.
- Maintain or increase soil health and organic matter content.
- Providing an additional source of organic matter to improve soil structure.
- Possible biocide effect on soil-borne diseases

CONS:

- Applying cover crops is site-specific: not all systems are equally suited to cover cropping. In some cases, existing long-season main crop rotations may differ from cover crops.
- In some cases, the cover crop's water usage may hurt main crop yields.
- Cover crops can increase pest risks, for example, by serving as an alternate host.
- Cover crops may compete with for water with the main crop, thus leaving the soil too dry. This can be harmful in drought conditions
- Increased costs: applying cover crops usually requires new equipment, and more complicated management practices by spending more.

Additional resources

Food and Agricultural Organisation of the UN (FAO) - Conservation Agriculture: Soil organic cover. https://www.fao.org/conservation-agriculture/in-practice/soil-organic-cover/en/

Sustainable Agriculture Research and Education (SARE) - Cover Cropping for Pollinators and Beneficial Insects – Limitation of Cover Crops. https://www.sare.org/publications/cover-cropping-for-pollinators-and-beneficial-insects/limitations-of-cover-crops/

U.S. Department of Agriculture (USDA) – Cover Crops and Crop Rotation. https://www.usda.gov/peoples-garden/soil-health/cover-crops-crop-rotation

U.S. Department of Agriculture (USDA) Risk Management Agency – Cover Crops. https://www.rma.usda.gov/Topics/Cover-Crops

BACK TO SOIL DEGRADATION PROCESS SELECTION

Crop residue incorporation

Description

After removing the marketable yield, crop residues can be removed or left in the field. The amount of residues produced by a crop varies with its Harvest Index, which is relatively high in cereals. Some crop residues have an economical interest, such as cereal straw that is used for livestock bedding, while residues of other crops can be incorporated, or sometimes even burnt as they may impede some tillage operations. Tree crops also produce residues, as leaves or pruning material.

As the production of cereal grains has increased globally, it was estimated that worldwide more than five billion tons of crop residues will bear annually produced worldwide in croplands (Jiang et al. 2014). Residues incorporation is considered an effective approach to sustain soil fertility, but also to recycle and retain nutrients in the farm.

Implementation

Crop residues may either be left on the soil surface or incorporated into the soil., depending on the tillage strategy and timing. Conventional tillage practices generally involve moldboard plowing, followed by secondary tillage by disking, harrowing or field cultivating. This strategy buries all crop residues in the soil. Crop residues are sometimes chopped to favour incorporation. When instead associated to No-till strategy, residues are left on the soil surface as mulching, a practice that protects the soil from compaction and erosion.

How does the strategy work in relation to the given threat?

Soil erosion

When the crop is incorporated into the soil, the organic matter content of the soil increases, which improves soil conditions. This promotes infiltration, water retention and generally improves soil quality. The soil also becomes more resistant to erosion.

Fertilizers / nutrient balance

Crop residues are a valuable source of organic compounds and nutrients that can be recycled through the incorporation into the soil. In general, the whole amount of nutrients contained in the residues are considered as available to the subsequent crop, although some mineralisation can occur, in particular if residues are incorporated into the soil long before the subsequent crop is sown or reaches a stage of active growth. If a residue has a very high C:N ratio, its degradation can immobilise N from the soil, and temporarily subtract it from the available pool. Therefore, for some types of residues such as cereal straw, especially in poor soils some N fertiliser is supplied. As the residues will eventually mineralise, this extra N should be only considered as an early application and should be counted in the nutrient management plan as an effective supply to the crop.

Biological activity

Crop residue incorporation is additional direct food source for soil decomposer communities, enhancing their biomass and density. It increases the above and belowground biomass of plants which indirectly increases the abundance and composition of soil biota. Adding organic matter to the soil enhances soil structure and increases the number of macropores which support the presents of mezzo and macro organisms in the soil.

Soil compaction

The increase of organic carbon through crop residue incorporation contributes to the elasticity of the soil and thus contributes to a better resilience against harmful soil compaction. However, the effect of incorporated crop residues and dead plant material regarding soil compaction is not as relevant as the impact of living cover crops on soil structure.

Soil structure

The incorporation of plant residues, mainly through increased organic matter content and reduction of soil surface desiccation, has a positive effect on soil structure. Still, the microbiome exceeds this effect in the living rhizosphere.

Soil organic carbon content

Crop residues represent a source of organic C that can influence the accumulation and decomposition of SOM (Kumar a Goh 1999). They are considered an important source of labile organic matter and nutrients and have a significant influence on the soil microbial and enzymatic activity. Residues incorporation can be an effective approach to sustain soil fertility, recycle and retain nutrients from the farm, and prevent soil organic carbon depletion (Dămătîrcă et al. 2023). Pooling together a large amount of experimental data across Europe, (Lehtinen et al. 2014) found that on average SOC increased by 7% following crop residue incorporation, with higher values for long-term repeated incorporations, and for clayey soils

Implementation challenges

This management practice can be carried out independently by the farmer. A stalk mulcher can be used to facilitate residue incorporation.

Necessary equipment and resources

This practice does not need specific equipment in the case of a conventional tillage strategy. If no-till or minimum tillage is performed, crop residues can harm seeding operation. A possibility is to use row cleaners, that help to clear surface residue out of the way of disk openers and prevent residue from getting into the seed furrow. Otherwise, the planter might require specific settings to adjust opening and closing of furrows, uniform seeding depth and seed-spacing.

Chopping residues can result in low soil temperature early in the spring, potential soil diseases, and early germination problems. Chopping residue also can reduce the protection that they offer to the soil surface from erosion, as chopped residue is no longer anchored into the soil. In addition, chopped residues will cause more problems at seeding as plugging planters.

Pros and cons of the strategy

If residues are left at the soil surface:

PROS:

- Protection of soil surface from erosion
- Protection of soil surface from compaction
- Reduction of weeds
- Reduction of runoff, increase in water infiltration

CONS:

- More attention is required at planting
- Lower soil temperatures
- More severe damages caused by some pests
- If residues are left at the soil surface or are incorporated into the soil:

PROS:

- SOM increase
- Reduction of fertiliser requirements
- Increased soil life
- Nutrient recycling in the farm

CONS:

- Reduction of farm income, if the residues can be sold

Additional resources

https://www.isqaper-is.eu/carbon-and-nutrient-management/crop-residue/425-retaining-crop-residues
https://www.conservationevidence.com/actions/907

BACK TO SOIL DEGRADATION PROCESS SELECTION

Mulching

Description

Mulching covers the topsoil with plant material such as leaves, grass, twigs, crop residues, and straw. The mulch cover increases the activity of soil organisms, such as earthworms. Mulching enhances soil structure by creating smaller and larger pores through which rainwater can easily infiltrate into the soil. Hence, it reduces surface runoff. As the mulch material decomposes, it increases the soil's organic matter content, hence contributing to creating a healthy soil structure. Thus, the soil particles will not be easily carried away by water; therefore, mulching is vital in preventing soil erosion.

Implementation

Mulching material can be weeds or cover crops, crop residues, grass, cuttings from hedges, also waster from agricultural processing or from forestry. The selection of the mulching material is site specific, and it depends on the application period. Materials which easily decomposes can protect the soil only for a short time, however, they provide nutrients to the crops. Hardy materials (such as cuttings from hedges) decompose more slowly and therefore they cover the soil for a longer time. Mulching is best to apply in rows or around single plants or evenly spread on the field. If the layer of mulch is thick enough, seeds or seedings can be directly sown or planted in between the mulching material. In vegetable fields, mulch is the best to apply after the young plants have become somewhat hardier, as the products decomposed from fresh mulch material may harm them. If mulch is applied before sowing or planting, the mulch layer should not be too thick to allow seedlings to penetrate it.

Figure 5. Mulched cover crops on the plots of the Mistelbach long-term experiment (Austria) (photo: Marton Toth).

How does the strategy work in relation to the given threat?

Soil erosion

The mulch material protects the soil surface from the impact of raindrops, which reduces the intensity of erosion. At the same time, it reduces evaporation from the soil, which supports the soil's water balance and improves its quality. The soil becomes more resistant to the erosive effects of rain and surface runoff.

Fertilizers / nutrient balance

The effect of mulching on fertilisation depends on the nature of materials used as mulching. Organic materials prone to mineralisation can represent a net supply of N, P and K when they are incorporated into the soil by a subsequent tillage operation or by soil fauna.

Biological activity

Mulching keeps preserving moisture in the soil and maintaining soil temperature which has a positive influence on the abundance and functioning of soil biota. By covering the soil surface, it can mitigate the physical disturbances such as erosion, sealing compaction thereby prevent the reduction of the number and composition of soil taxa. Organic mulching also provide an increased amount of organic matter stimulating the microbial abundance of the soil as well as the amount and biomass of earthworms.

Soil compaction

The protective effect of mulching and the increase of organic carbon contributes to a better resilience against harmful soil compaction. In combination with a reduction of soil disturbance, resilience against compaction can increase significantly. The effect of mulching without any adaption of tillage has low effects, though, and is not as relevant as the impact of living vegetation cover.

Martens a Frankenberger Jr. 1992 and Unger a Jones 1998 showed that addition of organic matter decreased soil bulk density. In contrast, other researchers have observed that mulching increased significantly (Bottenberg et al. 1999) or had no effects on bulk density.

Soil structure

The effects of mulching can vary with soil type, treatment, mulch type, and climate, so the results on the effects of mulching on bulk density, soil structure and porosity are not fully explicit. Mulching has an important role in runoff management techniques: it stores water to reduce runoff, regulates the movement of water over the soil surface, drains excess rainfall as runoff, or concentrates runoff from inadequate rainfall. It has a direct role in mitigating drip erosion that directly destroys soil structure. Mulching leads to an increase in earthworms, which in turn improves soil structure and porosity (Mulumba a Lal 2008; Rajkai et al. 2018).

Soil organic carbon content

The effect of mulching on the soil organic carbon content depends on the nature of materials used as mulching. Organic materials can represent a net supply of C to the soil when they are incorporated into the soil by a subsequent tillage operation or by soil fauna.

Implementation challenges

The mulching procedure must be carried out carefully for the target crop to be successfully grown. If crop residues are utilized for mulching, in some cases, there is an increased risk of sustaining pests and diseases. However, this issue can be overcome by paying attention to the application of crop rotations.

Necessary equipment and resources

The specific equipment needed can vary based on the local soil conditions, and topography. For example: disc mulchers, drum mulchers.

Pros and cons of the strategy

PROS:

- Protect soil from wind and water erosion by creating a healthy soil structure.
- Improves rain and irrigation water infiltration by creating a good soil structure.
- Provides shade to the soil, keeping the soil moisture and reducing evaporation.
- Increases soil organic matter content, feeds, and protects soil organisms.
- Provides nutrients to the crops by decomposing organic mulch material.

CONS:

- Crop - plant material interactions: Infected plant material with viral or fungal diseases should not be used if there is a risk that the disease might spread to the next crop.
- Survival of crop pest or disease germs from the previous crop.
- Crop rotation is essential to overcome these risks.
- Risk of nitrogen immobilization if carbon-rich material is utilized, organic materials with C:N ratios of less than 20:1 release nitrate-nitrogen that could cause water-quality impairments.

Additional resources

Food and Agricultural Organisation of the UN (FAO) - Mulching in organic agriculture. https://www.fao.org/family-farming/detail/en/c/1617795/

Food and Agricultural Organisation of the UN (FAO), Technologies and Practices for Small Agricultural Procedures (TECA) - Mulching in organic agriculture. https://teca.apps.fao.org/en/technologies/8365/

U.S. Department of Agriculture (USDA) – Got Weeds? Need to hold water in the soil? https://www.usda.gov/peoples-garden/soil-health/mulch

U.S. Department of Agriculture (USDA). 2020. Summary Report: 2017 National Resources Inventory, Natural Resources Conservation Service, Washington, DC, and Center for Survey Statistics and Methodology, Iowa State University, Ames, Iowa. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri/results/

BACK TO SOIL DEGRADATION PROCESS SELECTION

Grassing

Description

Grassing is utilized to protect the bare soil surface from raindrop impact, sheet erosion, or minor rill erosion, and it can also be used to minimize sedimentation into surface water bodies.

Implementation

Grassing or grass-seeding is applied on sites to reduce the risk of water erosion and the effects of sedimentation. The vegetative cover and root system in the waterways slow the runoff water flow and protect the channel from erosion. Before the grassing is designed, it is essential to assess the pH, fertility, and steepness of the soil, decide on the type of seed mix, consider if it is adaptable to the local soil types(s) and environment, and the associated logistics of fertilizer to the site. The grassing is most successful during spring or autumn when the soil moisture is higher, the rainfall is evenly distributed, and the soil temperature, moisture, and sunlight for germination and growth are optimal. The seeding process can be carried out by hand, hand-help spreader, or aerial application, depending on the size of the grassed area. It is essential to prepare a routine maintenance plan for the grassed area, including response measures after heavy rainfall events.

Figure 6. Grassed waterway in Mistelbach (Austria) (photo: Marton Toth).

How does the strategy work in relation to the given threat?

Soil erosion

Greening provides effective protection of the soil surface from raindrops. At the same time, it increases soil retention by trapping it on the plant surface and promotes soil retention through root activity. The presence of grass also slows down surface runoff and traps transported soil particles. This contributes significantly to protection against soil erosion.

Fertilizers / nutrient balance

The conversion of agricultural land into permanent grassland affects the fertilisation strategy, that must be adapted to the new land use in terms of crop requirements and fertilisation timing. The calculation of nutrient requirements of a grassland is more difficult than that of crops, because of i) difficult estimation of provisional yield, ii) difficult estimation of N concentration of yield and of nutrient uptake, iii) difficult estimation of the contribution of N fixation contribution to N mass-balance.

Biological activity

Grasslands have one of the highest living biomasses belowground. It has the highest number of earthwork population and arthropod communities as well as one of the most species rich AMF communities. Intensively managed grasslands got a more bacterial-based food web as less managed species-rich grasslands got a fungal based food web. In general, with increasing age of grasslands the number and diversity of soil biota increases. Similarly, with diversified plant communities the soil biological community also become increasingly divers.

Soil compaction

Grassing is a conservation technique for the prevention and alleviation of harmful soil compaction. Above ground biomass and roots provide nutrition to soil life organisms which provide good soil structure, roots also loosen the soil during growth. Furthermore, even dead cover material protects the soil from erosion and serves as food for soil life organisms.

Soil structure

Grassing is accompanied by many biotic and abiotic factors that affect soil regeneration, especially when cultivated land is converted. Grassing improves soil biological activity (including the permanent root system), which has a positive effect on soil structure and porosity. A nearly 20-year experiment on grassland restoration showed that the average weighted diameter of soil aggregates showed a strong increase due to an exponential increase in the proportion of large macroaggregates (>2000 μm) (Bach et al. 2010).

Soil organic carbon content

The conversion of arable land into grassland will case an increase in SOM content (Schils et al. 2022). This positive outcome will occur only after several years but in the long term the increase can be in the range 27-37% (Eze et al. 2023).

Implementation challenges

It must be ensured that the grass seeds are distributed directly in the area, which can be difficult for larger areas if the aerial application is carrying out the grassing. Grassing can be implemented if the surface is not so steep the seed will wash off, nor on earthworks sites that are heavily compacted.

Necessary equipment and resources

Depends on the grassed area, it can be carried out by hand, hand-help spreader or aerial application.

Pros and cons of the strategy

PROS:

- Protect soil from surface runoff and reduce erosion significantly.
- Help to improve water quality.
- Provide habitats for wildlife, especially areas where arable farming dominates.
- Provide a buffer zone between the sensitive habitats and farming activities.
- Essential to sustainable livestock production, ecosystem balance and carbon sequestration.
- Low managing costs.

CONS:

- On arable lands, Equipment must be raised or sprayers shut off when crossing on a grassed area
- Some maintenance is necessary periodically so that gullies don't form along the edges.

Additional resources

Institute of Agriculture and Natural Resources - Grassed Waterways a Standard for Erosion Control. https://cropwatch.unl.edu/grassed-waterways-standard-erosion-control

Forest Owners Association – Vegetation to Manage Erosion – Grassing (2.0). https://docs.nzfoa.org.nz/forest-practice-guides/vegetation-to-manage-erosion/5.1-vegetation-to-manage-erosion-grassing/

GOV.UK – Create and maintain grass strips. https://defrafarming.blog.gov.uk/create-and-maintain-grass-strips/

BACK TO SOIL DEGRADATION PROCESS SELECTION

Strip cropping

Description

Strip cropping involves growing row crops, forages, small grains, or fallow in a systematic arrangement of equal-width strips across a field. Strips mitigate and reduce the risk of water – and wind erosion, reduce particulate emissions into the air, and improve water quality.

Implementation

Strip cropping technique is utilized on croplands and particular recreation - and wildlife lands where field crops are grown. The crops must be arranged in order. Therefore, a grass or close-growing crop strip is alternated with a clean-tilled strip or a strip with less protective cover. Generally, the strip widths are equal across the field. On sloping fields affected by sheet and rill erosions, the strips are laid out on the contour or across the general slope (field strip cropping). For fields affected by wind erosion, the strips are laid out as close to perpendicular as possible to the prevailing erosive wind direction (wind strip cropping). Besides the erosion control, strips can be designed for biological pest control (flower strips), increasing biodiversity (strip intercropping), or created on a farming scale (strip farming: 50 m wide, where cereals and fallow strips alternate year to year), or designed as a combination of contour farming and strip cropping (contour strip cropping), where the area is highly affected by water erosion.

Figure 7. Strip cropping in Austria (Goméz et al., 2021).

How does the strategy work in relation to the given threat?

Soil erosion

Strip cropping – crop strips with a higher and lower protective effect against erosion makes it possible to better control the intensity of erosion on an individual plot. On the one hand, belts with protective cropping eliminate the formation of erosion and surface runoff in the area of the belt. At the same time, their presence interrupts the length of the plot, thereby contributing to protection against erosion even on the part of the plot without protective crops. Crop rotation also contributes to a better management of nutrients in the soil, which makes it possible to maintain good soil properties and its overall resilience.

Fertilizers / nutrient balance

No significant positive impact, at least at a single crop level.

Biological activity

Strip cropping increases plant diversity resulting in increased diversity of residues and root systems thereby supporting a wider diversity of soil biota.

Soil compaction

Strip-cropping has no particular effect on the compaction status of the soil. However, all positive effects of erosion control and soil structure improvement ultimately also increase the soils' resilience against harmful soil compaction.

Soil structure

Strip-cropping does not have a direct effect on soil structure, but the diverse plant root zone and the associated diverse microbial community promote soil structure formation. Roots release organic compounds, such as polysaccharides and proteins, which act as binders, helping soil particles to stick together and form aggregates.

Soil organic carbon content

No significant positive impact, at least at a single crop level.

Implementation challenges

The implementation of strip cropping is diverse; if Strip cropping is (usually) designed to reduce the negative effects and risk of water – and wind-soil erosion, it is important to assess the local soil types and soil - and micro-topographical conditions. It must be acknowledged that implementing this conservation technique requires complex planning, intensive labour, and extra equipment because different crops have different needs, and they need to be managed simultaneously.

Necessary equipment and resources

The specific equipment selection is based on the type of strips we aim to design (e.g., flower strips, contour strips), soil type, crop types among the strips, and the local soil - and micro-topographical conditions.

Pros and cons of the strategy

PROS:

- Erosion control
- Improves water quality.
- Improves wildlife habitat and biodiversity.
- Pests and disease control
- Increases infiltration capacity and available soil water.
- Reduces sediment transport and other waterborne contaminants.
- Increases soil fertility.
- Protects growing crops from the damage of windborne soil particles.
- Landscape diversification.

CONS:

- Requires complex planning (different crops have different needs)
- Needs to pay attention to the limited crop choices (efficiency of different types of crops grow together)
- Labour intensive
- Costs and equipment limitations (specialized or additional farming equipment might be needed to handle different crops at the same time)
- Potential negative impacts on crop yield

Additional resources

United States Department of Agriculture (USDA) – Conservation Practice Overview, Stripcropping. https://www.nrcs.usda.gov/sites/default/files/2022-10/Stripcropping_Overview_585_Oct_2017_final.pdf

Interactive Soil Quality Assessment Inofrmation Systems (iSQAPER) – Strip cropping. https://www.isqaper-is.eu/vegetation-management/vegetation-bands/382-strip-cropping

Earthhow – Strip Cropping: The Benefits of Green Stripes. https://earthhow.com/strip-cropping/

Food and Agriculture Organization of the United Nations (FAO) – Diversified cropping system: strip cropping. https://www.fao.org/family-farming/detail/en/c/1619906/

BACK TO SOIL DEGRADATION PROCESS SELECTION

Contour farming

Description

Contour farming is a technique where sloped agricultural land is managed and tilled along lines of consistent elevation. With this practice, water erosion can be reduced and rainwater is better kept on site. The reduction of erosion and the retention of water is achieved by furrows, crop rows, and wheel tracks across slopes. These elements act as rain and irrigation water reservoirs which increase local infiltration and more uniform moisture distribution.

Implementation

Contour farming is often implemented in erosion-prone and irrigated areas. An implementation is most effective on slopes with gradients between 2 and 10%. On steeper slopes, an implementation of additional conservation techniques is recommended (e.g., strip cropping, terrace farming, cover cropping). At implementation of contour farming, it must be considered to prevent too long, smooth, even slopes. Conservation practices can be used to shorten the slope lengths and to make them more irregular, which decreases surface flow.

Figure 8. Contour farming and strip cropping on sloping farmland. (Encyclopædia Britannica; © Sunset Avenue Productions—DigitalVision/Getty Image; https://www.britannica.com/topic/organic-farming#/media/1/135192/149126).

How does the strategy work in relation to the given threat?

Soil erosion

Contour farming creates furrows and rows of crops. These objects can capture surface runoff and eliminate the intensity of soil erosion. This method is very complex in terms of management accuracy and application. Efficiency is limited by the capacity of the row and furrow system. For high intensity of precipitation or in areas with high intensity of erosion, this measure is not very effective.

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

Contour farming promotes the biological activity of the soil by reducing soil disturbance and preserving soil structure. It prevents soil erosion and improves moisture retention creating a favorable environment for soil microorganisms. This increased microbial activity helps improve nutrient cycling, soil structure and overall ecosystem resilience.

Soil compaction

The technique of contour farming is not directly linked to the problem of soil compaction. However, all positive effects of contour farming also strengthen soil structure and thus make the soil more resilient against harmful soil compaction. Particularly the accumulation of organic carbon, the decreased soil loss through erosion processes, and the improved soil stabilization by plants through improved water availability serve as soil compaction protection.

Soil structure

Contour farming reduces the rate of tillage erosion, comparing to cross-slope cropping, and less soil (especially the material of the organic rich upper layer) is carried downslope for long distances. The downslope erosion does not primarily affect the stability of the soil aggregates, but the removal of soil material, which is easily displaced by water, mainly of loam texture, and which could potentially form a good structure when combined with organic matter. Contour farming promotes to preserve soil moisture and nutrients, and helps to improve soil structure by keeping aggregated soil material in place.

Soil organic carbon content

No significant positive impact.

Implementation challenges

Contour farming is most effective on slopes with gradients between 2% and 10%. For steeper slopes a combination with **strip cropping** should be used to provide the needed additional roughness and protection. Anyway, contour farming is most effective when used with other soil conservation methods like strip cropping, terrace farming, and the use of cover crops. In case that the intersections of crop rows with the field edge is not perpendicular, a field border may be needed as reversal possibility. Contour farming in combination with residue management or ridge tills, the crossing of ridges should be avoided.

Necessary equipment and resources

The contour farming technique uses ridges and furrows formed by tillage, planting and other farming operations to change the direction of runoff from directly downslope to around the hillslope. Thus, no additional equipment or resources are needed for this practice.

Pros and cons of the strategy

Contour farming under ideal implementation preconditions (slopes between 2 and 10%) is considered to reduce fertilizer loss, power and time consumption, and soil erosion compared to conventional tillage management. Particularly the erosion control function by contour farming helps to absorb the impact of heavy rains and reduces fertilizer loss. Consequently, crop yields can be increased and regional freshwater systems are protected from eutrophication.

It should be considered, that at one end of each contour the slope of the land will always be steeper than at the other. Thus, the plough furrows soon deviate from a true contour and the water in the furrows will flow along the falling contour line. This may lead to concentrated water ways, which could have even a negative effect on erosion control. However, this additional drift may be alleviated with cultivating furrows to control the movement of rain water.

Additional resources

Contour-Farming-and-Strip-Cropping.pdf (bmpbooks.com)

(4) Farming Methods of Agriculture | What is Contour Farming? | Contour Plowing | Contour Bunding - YouTube

BACK TO SOIL DEGRADATION PROCESS SELECTION

Sustainable crop rotation

Description

As climate change and global food demand continue to grow, agricultural practices must adapt to ensure the sustainability in the future. Sustainable crop rotation, planting a different crop on a particular land each growing season is required in crop production, also preventing soil diseases, insect pests and weeds, minimizing soil depletion, and also adapting to the challenges in climate change for building healthy agricultural soils for the future generations.

Implementation

Crop rotation must fit with the applied production systems, equipment, farm labor, the market demand for the farm's crops, and the challenges of climate change. For the successful implementation of the crop rotations, it is essential to follow some general principles, for instance:

- Grow annual crops for only one year in a particular location.
- Do not follow one crop with another closely related species.
- Follow a legume crop (e.g., soybean) with a high-nitrogen-demanding crop.
- Use crop sequences that promote healthier crops and control weeds.

To mitigate the effects of soil erosion, using more extended periods of perennial crops on sloping land is beneficial. Also, for nutrient cycling, it is necessary to pay attention to growing some crops that will leave a significant amount of crop residue.

How does the strategy work in relation to the given threat?

Soil erosion

Crop rotation affects nutrient cycling in the soil. Sustainable crop rotation does not deplete the organic material of the soil. Soil with a higher content of organic material is more resistant to precipitation and surface runoff and consequently more resistant to erosion.

Fertilizers / nutrient balance

The rotation allows better distributing nutrients to soil and plants, as scarcely-mobile nutrients (P and K) can be allocated to some crops in the rotation only, in order to reduce distribution costs, while the other crops will utilise the legacy. However, the overall supply should be balanced to the sum of the uptakes of all crops in the rotation.

Biological activity

Sustainable crop rotation increases plant diversity resulting in increased diversity of residues and root systems thereby supporting a wider diversity of soil biota. It improves the physical structure of the soil which supports the development of microhabitats for soil biomes. The use of sustainable crop rotation contributes to pest and disease control and retrieve available nutrients that provides favourable conditions for soil biota.

Soil compaction

A sustainable crop rotation fosters a good soil structure and protects against unbalanced nutrient deficiency, which improves a stable soil life activity. Furthermore, a broad range of root depth and density loosens the soil in different layers. Thus, a sustainable crop rotation as part of good soil management contributes to the prevention of degradation processes, including harmful soil compaction.

Soil structure

Crop rotation and manure application are the most common agricultural practices that reportedly improve soil physicochemical properties (Fu et al. 2022). As a result of a mid-term experiment on clayey soil, additional cover crop inclusion in a crop rotation improved the hydraulic properties and significantly enhanced soil water retention after 5 years (Çerçioğlu et al. 2019). The different rooting depths of crops grown in rotation help to develop and maintain topsoil structure.

Soil organic carbon content

Crop rotation increases SOC content and crop yields (Bai et al. 2018; Gregorich et al. 2001). In addition, it promotes the functional complexity of SOM (Lehmann et al. 2020) by stimulating diverse microbial populations and rhizodeposits. Crop rotation, especially legume-based rotations, increases the proportion of aromatic and carbonyl groups, and negatively affects the alkyl groups. The reason is that crop rotation stimulates a diverse microbial community and rhizodeposits, and in addition it provides a higher amount of labile C consisting of O-alkyl C structures as plant biomass relative to a continuous monoculture (Audette et al. 2021).

Implementation challenges

Adapting sustainable crop rotations requires advanced, complex planning. Farmers must take into account the specific needs of planted crops. Also, their growth habits, pest susceptibilities, and climate constraints are essential for some crops that may not be suitable for rotation because of specific climate conditions. The application can be challenging for small-scale farms due to the limited land. The type of the planted crop will not be independent of the market demand and crop value.

Necessary equipment and resources

The equipment selection is based on the applied crops, local climate – and soil conditions, and micro-topographical conditions.

Pros and cons of the strategy

PROS:

- Disease and pest control
- Soil fertility management
- Weed management
- Erosion control
- Improved crop yield
- Biodiversity enhancement
- Resilience to weather variability
- Sustainability
- Possibility to calculate nutrient requirements based on the crop rotation and not to a single crop, thus distributing less mobile nutrients – P and K – only to the most sensible crops in the rotation

CONS:

- Requires advanced, complex planning
- Limited land on small-scale farms
- Market demand and crop value
- Climate constraints
- Pest and disease persistence

Additional resources

United States Department of Agriculture (USDA) – Cover crops and Crop Rotation. https://www.usda.gov/peoples-garden/soil-health/cover-crops-crop-rotation

United States Department of Agriculture (USDA) – ATTRA Sustainable Agriculture – tipsheet: Crop Rotation in Organic Farming Systems. https://www.ams.usda.gov/sites/default/files/media/Crop%20Rotation%20in%20Organic%20Farming%20Systems_FINAL.pdf

Sustainable Review – Sustainable Crop Rotation Practices. https://sustainablereview.com/sustainable-crop-rotation-practices/

Food and Agriculture Organization of the United Nations (FAO) – Sustainable crop rotations. https://www.fao.org/3/v9926e/v9926e06.htm

BACK TO SOIL DEGRADATION PROCESS SELECTION

Vegetated buffer strips

Description

Vegetated buffer strips are designated areas in agricultural landscapes that are either left uncultivated or planted with perennial grasses, shrubs and trees to serve as natural barriers. These strips, often referred to as grassed or vegetated barriers, are strategically placed over areas prone to concentrated water flow or along the contour of slopes. They can also be placed near streams, roads, ditches and other protected areas to intercept and prevent the deposition of eroded soil (Prosser et al. 2020). In this way, buffer strips play a crucial role in reducing soil erosion and mitigating the risk of flooding, thereby maintaining the integrity of the landscape and protecting valuable water resources.

The main objective of vegetated buffer strips is to improve the resilience of agricultural landscapes to the negative impacts of climate change and intensive agricultural practices. These strips act as a filter by retaining sediments and nutrients before they can contaminate groundwater or nearby water bodies, thus reducing pollution. They also help to moderate the speed and volume of water flow by absorbing runoff, reducing the likelihood of flooding. This conservation measure not only protects soil health and water quality, but also contributes to biodiversity by providing habitats for different species, supporting the stability of the ecosystem as a whole (Hodgson 2023).

Figure 9. Vegetated buffer strip along the stream in the Czech Republic (Josef Krása).

Implementation

There are two main categories of buffer strips, depending on their location in the agricultural landscape: Field margin strips and riparian buffer strips. Field margins are created across the plot along contours, while riparian buffer strips are created around watercourses. The composition of vegetation within buffer strips varies, resulting in three different types: grassed buffer strips, which consist of grasses and wildflower species; wooded buffer strips, which consist of tree and shrub species; and integrated or constructed buffer strips, which contain a mixture of species and sometimes include earthworks.

Riparian buffer strips are widespread throughout Europe. They are usually 6-10 meters wide and are located at the edges of farmland adjacent to watercourses. The most effective riparian buffer strips often use a three-zone structure as recommended by Christen a Dalgaard (2013). This structure includes a grass strip to reduce the velocity of surface runoff, filter sediment, and minimize erosion; a forest strip with deep-rooted tree species to stabilize banks, absorb precipitation, and filter nutrients and pollutants; and an undisturbed strip to protect planted areas during flooding and further reduce bank erosion. Importantly, buffer strips must not be fertilized or treated with pesticides or herbicides, and their width is usually determined by local legislation. The optimal composition of the grass strip is primarily influenced by the slope of the land to ensure maximum effectiveness in preventing erosion and protecting water quality (Hodgson 2023; Prosser et al. 2020).

How does the strategy work in relation to the given threat?

Soil erosion

Grassed buffer stripes are very effective in trapping sediment, runoff and nutrients, thereby reducing hydrological and sediment connectivity across the landscape. Intensive use of vegetation creates a permanent obstacle to runoff that reduces its velocity, favouring infiltration and sedimentation. In a recent review, Muñoz et al. (2023) claim that in most cases, a vegetative barrier will reduce erosion, but with a large variability in the effectiveness results. This variability is relevant due to environmental conditions and design.

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

Vegetation buffer strips increases plant diversity resulting in increased diversity of residues and root systems thereby supporting a wider diversity of soil biota. It improves the physical structure of the soil, improves moisture retention as well as retaining organic residues, creating a favorable environment for soil microorganisms. The remaining crop residues serve as a source of nutrients and promotes the growth of beneficial bacteria and fungi.

Soil compaction

Vegetated buffer strips are areas with undisturbed soil and permanent vegetation cover, which are the most effective strategies to improve soil structure and to prevent harmful soil compaction. The buffer strips prevent erosion processes and thus retain the carbon-rich topsoil on the field, which increases the elasticity of the soil. Furthermore, above ground biomass and roots provide nutrition to soil life organisms which provide good soil structure throughout the year. Thus, vegetation buffers may be considered to have a positive effect on the strips' area as well as on the entire field.

Soil structure

Planting vegetated buffer strips and hedges, which mainly mitigate the effects of wind erosion, helps to maintain the humus rich layer at the soil surface and to retain the less structured soil material that can be easily displaced by wind.

Soil organic carbon content

No significant positive impact.

Implementation challenges

The establishment of vegetated buffer strips poses several challenges for farmers. They have to make part of their agricultural land available for these strips, which can reduce the area available for crop production and potentially affect their income. There are also financial costs associated with the establishment and maintenance of these buffer strips, including the purchase of seeds or plants and ongoing management costs. The effectiveness of buffer strips also depends on choosing the right composition of vegetation, which varies according to specific site conditions such as soil type, slope and climate. This requires farmers to have or acquire knowledge of the best species and configurations for their particular site, which adds to the complexity and expense of effectively implementing this conservation measure.

Necessary equipment and resources

The location of the buffer strip must be determined using an appropriate method that takes into account the main purpose of the strip and the specific local conditions such as slope, erosion intensity, and the presence of watercourses. This site assessment serves as the basis for the design of the buffer strip, including its dimensions and the types of vegetation to be used (grasses, shrubs, trees). Once the design is complete, the buffer strip can be created manually, requiring seeds or plants for the chosen vegetation as well as planting tools such as seeders or spades. For ongoing maintenance, suitable tools such as lawn mowers or brush cutters are needed to control the growth of the vegetation and ensure that the buffer strip fulfils its function. In addition, funding must be provided for both the initial establishment and ongoing maintenance of buffer strips to maintain their functionality and ecological benefits.

Pros and cons of the strategy

PROS:

- Increased infiltration capacity and slowing of surface water runoff
- Erosion control
- Deep rooting perennial plants and tree species can act as a biological filter that absorbs and utilises nutrients before they reach watercourses
- Buffer strips provide important habitats and can provide cover for wildlife to move freely between different habitats which are often fragmented by field boundaries

CONS:

- Arable land reduction
- Source of weeds
- Yield reduction
- Financial costs for maintenance

Additional resources

https://abe.ufl.edu/faculty/carpena/files/pdf/software/vfsmod/VFS_Flyer_07_09_09__FINAL.pdf
https://www.chisagocountymn.gov/DocumentCenter/View/4059/Vegetation-Buffer-Strips-in-Agricultural-Areas-PDF
https://bmpbooks.com/media/Buffer-Strips-Factsheet.pdf

BACK TO SOIL DEGRADATION PROCESS SELECTION

Hedgerows

Description

Historically, hedges originated as boundaries between individual parcels of land, were aligned horizontally and were formed in terraced steps. This thin linear feature was then stabilized by bushes or trees. Newly planted hedgerows have been usually created as simple, low, horizontally aligned structures, with trees and shrubs planted to enhance the ecological effects in the landscape. Such Hedgerows have no influence on the steepness of the slope.

The terrain steps at the hedgerows have been formed by annual contour ploughing and insertion of stones from the field into the boundary line. This line has then been used/stabilized by vegetation – usually fruit trees/shrubs.

Newly established hedgerows in Europe are usually created as simple, low embankments that are aligned horizontally, stabilized with larger stones and planted with trees and shrubs to improve ecological stability of the landscape.

Another option are grass hedgerows, which are rows of grass planted along contour lines, usually in areas with steep slopes. They facilitate the deposition of eroded material from the slope by reducing overland flow and water velocity.

Implementation

The creation of a new hedge begins with the planting of a suitable grass mixture. The grass initiates the renewal of the nutrient cycle and prepare the soil conditions for the planting of woody plants. Resistant tree species, which are undemanding and can withstand adverse conditions, are then planted. Over time, the less resistant trees can be added, which will form the basis of the newly formed plant community. The suitability of the individual shrub and tree species depends on the local conditions. A shallow planting method is suitable.

The new hedge must be maintained. The site for the new hedge should be fenced off to protect it from wild animals. It will initially require suitable watering (more frequent application of small amounts of water). The hedge grass must be trimmed regularly.

Figure 10. Left – hedge from above, right: the same hedge after severe storm event (Tomas Laburda).

How does the strategy work in relation to the given threat?

Soil erosion

Historically developed hedges have the effect of reducing slope steepness, limiting surface runoff, initiating and accelerating the sedimentation of eroded material and creating biologically very valuable bio corridors in the agricultural landscape.

Modern hedgerows have no significant influence on the slope gradient. In order to retain or divert surface runoff, they must be equipped with a ditch above the hedge.

Grass hedgerows reduce the length of the slopes and thus reduce the distance for soil movement. The hedgerows also trap sediment over time and form terraces, ultimately reducing the slope of the field and thus reducing soil erosion (Blanco-Canqui a Lal 2008).

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

Hedgerows create a less compact soil environment with a greater number of micro and macro pores providing living space for a diverse composition of soil fauna. The permeability of the soil around the hedgerows also increases thereby supporting a higher level of water infiltration and minimising soil erosion. This supports the abundance of macro-organisms such as earthworms and collembolas. Additionally, the fallen biomass (e.g., leaf, branches) from the hedgerows provide a carbon and nitrogen source for soil biological activity and living habitat for a wide range of soil biome. The year around nutrient and water supply in the hedgerow's rhizosphere creates a balanced soil microbial community aiding the suppression of pathogens.

Soil compaction

Hedgerows naturally prevent any soil compaction on their cultivation area, as these areas are not trafficked, the soils are undisturbed soil, and the permanent vegetation provides nutrition to soil life organisms which provide good soil structure throughout the year. In their main function, hedgerows effectively prevent erosion processes and thus retain the carbon-rich topsoil on the field, which increases the elasticity of the soil. Thus, hedgerows are a crucial measure to raise resilience against harmful compaction on the entire field.

Soil structure

Planting vegetated buffer strips and hedgerows, which mainly mitigate the effects of wind erosion, helps to maintain the humus rich layer at the soil surface and to retain the less structured soil material that can be easily displaced by wind.

Soil organic carbon content

Hedgerows have positive impact on soil organic carbon concentration. The soil under hedgerows shows an increase in organic carbon concentration (Holden et al. 2019).

Implementation challenges

If the hedge is planted under unsuitable conditions, the grass seeds can be washed away. As a result, the water cycle and the nutrient balance will not be restored.

During the establishment of a hedge, the new undergrowth can be damaged by pests. An inappropriately selected species composition of trees that are not sufficiently resistant to the local conditions also poses a risk.

Necessary equipment and resources

The farmer must make part of the arable land available for the planting of a hedge. A suitable mixture must be provided for the planting. The planting can be done by hand or with a hand spreader or from the air. Suitable and resistant trees must then be selected and planted, which will be supplemented by more demanding trees in the longer term. The maintenance of a hedge also includes the cost of watering and regular mowing.

Pros and cons of the strategy

PROS

- Help reduce soil erosion by stabilizing the soil with their root systems and reducing the velocity of surface runoff.
- The roots of hedgerows improve soil structure by increasing soil porosity and promoting the formation of soil aggregates.
- Provide habitat for a variety of plants, animals, and microorganisms, increasing biodiversity in agricultural landscapes.
- Contribute to nutrient cycling by capturing and recycling nutrients that might otherwise be lost from the ecosystem.
- Can improve water infiltration and retention in the soil, reducing surface runoff and mitigating the risk of flooding.
- The biomass of hedgerows, including their roots, contributes to carbon sequestration, helping to mitigate climate change.
- Act as windbreaks, protecting crops from wind damage and reducing wind erosion.

CONS:

- Can compete with adjacent crops for water, light, and nutrients, potentially reducing crop yields.
- Require regular maintenance, including trimming and managing plant health, which can incur additional costs for farmers.
- Can harbor pests and diseases that might spread to adjacent crops, posing a risk to crop health.
- Can reduce the amount of arable land available for crop production.
- The initial cost of establishing hedgerows, including planting and potential fencing, can Be significant.

Additional resources

https://ptes.org/wp-content/uploads/2020/05/Healthy-hedgerows-and-key.pdf
https://hedgelink.org.uk/guidance/importance-of-hedgerows/
https://www.tucson.ars.ag.gov/icrw/Proceedings/Alberts2.pdf

BACK TO SOIL DEGRADATION PROCESS SELECTION

Reservoir tillage

Description

Reservoir tillage is an innovative agricultural method that has a significant impact on soil health and water management, especially in regions with difficult climatic conditions such as the Mediterranean. The use of these tillage methods is also widespread in regions with highly variable field topography, where water distribution can be uneven and problematic. are particularly common in row crops such as potatoes, corn, and cotton. These crops benefit significantly from these practices due to their specific water requirements and the structure of their planting.

Conservation tillage involves creating depressions or basins in the soil that fulfill multiple functions. These practices are particularly beneficial for reducing runoff and preventing soil erosion. By capturing and retaining water in the field, these methods allow for better infiltration and percolation of water in the soil profile. This process not only increases the availability of moisture in the soil, but also reduces the energy of surface runoff, minimizing soil erosion and degradation. The improved soil structure resulting from these practices increases porosity and aggregate stability, further contributing to soil health and resilience. Reservoir tillage implements a subsoiler or a chisel shaft followed by a paddle wheel with blades attached to the spokes of the paddle wheel that penetrate the soil and dig small reservoirs. The subsoiler loosens the soil and the blades of the paddle wheel create small depressions to retain water (Salem et al. 2015).

Figure 11. Machinery to implement reservoir tillage in potato field (Matthias Konzett).

Implementation

The retention tillage begins with the use of a subsoiler or chisel, which is crucial for breaking up the soil, especially the deeper compacted layers. This first step helps to reduce soil compaction and allows for deeper water penetration and better root growth. After the subsoiler, a paddle wheel equipped with blades attached to the spokes is used. These blades dig into the soil to a depth of around 0.25 to 0.3 m, creating small water reservoirs or depressions along the field rows.

These depressions serve a dual purpose: they improve the soil's ability to capture and retain water from rainfall or irrigation and improve the overall infiltration and percolation of water through the soil profile. The structured depressions left by tillage equipment allow for more efficient water use and ensure that plants receive sufficient moisture even during dry periods. By changing the soil structure, which leads to better aeration and less surface compaction, tillage in reservoirs also helps to reduce soil erosion and runoff. This not only protects the fertility of the soil, but also reduces the risk of fertilizers and chemicals being washed into nearby water bodies, promoting a healthier agricultural ecosystem and better crop yields.

How does the strategy work in relation to the given threat?

Soil erosion

Reservoir tillage effectively mitigates soil erosion by creating depressions in the soil that act like mini pools, trapping and retaining water and thus reducing runoff. By breaking up compacted soil layers, water infiltration is improved and the erosive force of overland water flow during rain or irrigation is reduced. This improved soil structure not only prevents soil particles from being washed away, but also preserves soil moisture, making the soil less susceptible to erosion. The resulting stable, moist soil environment preserves soil health and fertility, which is crucial for sustainable agricultural practices.

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

This tillage method enhances organic matter and soil structure by reducing compaction and improving porosity, which facilitates better air and water flow through the soil. Such conditions are favourable for soil organisms, as they rely on moisture and air. These conditions enable microorganisms to break down organic matter more efficiently, releasing nutrients that are essential for plant growth. Additionally, the improved soil structure provides a more hospitable environment for earthworms.

Soil compaction

This tillage technique uses tools like subsoilers and chisel shanks that penetrate deeply into the soil, breaking up compacted layers that restrict root growth and impede water and nutrient flow. By disrupting these dense layers, reservoir tillage enhances soil structure, increasing porosity and permeability. This improvement allows roots to penetrate deeper into the soil, accessing more nutrients and water.

Soil structure

This tillage has no crucial effect on soil structure, but it does make a positive contribution to improving soil structure, increasing porosity and permeability.

Soil organic carbon content

No significant positive impact.

Implementation challenges

One of the main problems is the initial cost and availability of specialized equipment needed for this type of tillage. Subsoilers, chisel shanks and paddle wheels with blades are specialized tools required to create the appropriate soil depressions, and these can represent a significant investment for farmers, especially smallholders.

The effectiveness of reservoir tillage can be highly dependent on local soil conditions and climate. In areas with heavy, clayey soils or in regions prone to heavy rainfall, depressions can fill too quickly and overflow, causing erosion rather than preventing it. This requires precise management and sometimes an adjustment of the cultivation depth and spacing of the depressions to local conditions.

Necessary equipment and resources

Special machines are required for working the soil in reservoirs, such as subsoilers, chisel shanks and paddle wheels with blades. Subsoilers are used to break up compacted soil layers deep below the surface, while chisel shanks further loosen the soil and improve its structure and permeability. Paddle wheels with attached blades are then used to carve out the small reservoirs at specific depths. Given the variety of machine designs and the specific requirements resulting from the soil type, topography and local climatic conditions, it is advisable to seek advice from an agricultural expert when choosing the type of equipment.

Pros and cons of the strategy

PROS:

- Minimizing the runoff and
- Soil erosion prevention
- Surface waters protection

- Improves soil health
- Helps capture and retain soil water, reducing irrigation needs and enhancing drought resilience
- Increasing soil porosity and promoting better root penetration and aeration

CONS:

- Initial financial costs for the specialized equipment
- Not universally effective across all soil types; may be less effective in very sandy or heavy clay soils
- Reservoir tillage is not suitable for all crops and agricultural parcels

Additional resources

Reservoir Tillage 850 (youtube.com)
Reservoir Tillage 850 - Optimize Water Infiltration (youtube.com)

BACK TO SOIL DEGRADATION PROCESS SELECTION

Retention ditches

Description

A retention ditch catches surface runoff, allowing this was water to infiltrate locally. Therefore, the retention ditch is oriented with zero/minimum slope and to support infiltration, often it is provided with a drainage pipe in the bottom of the element. To prevent overflow, it can be designed with mild longitudinal inclination and equipped with small retention barriers, which can be overflown. Or with zero longitudinal slope, but equipped with emergency spillway, which will lead excess runoff securely into recipient.

Implementation

Retention ditches are dimensioned/designed based on the volume of runoff from the design rainfall. Ditches usually have a trapezoidal profile with a bottom width of at least 0.6 m (according to of the volume of runoff from the design rainfall). Slope slopes 1:1.5 - 1:10. Ditch depth 0,6-1,5°m.

The periodicity of design rainfall event depends on potential damages at protected structure and usually varies between 5 years (for case of low value structures) to 100 years of return period (for protection of urban areas).

This measure can effectively be designed only in the areas with well permeable soils (Saturated hydraulic conductivity $K_{sat} \geqslant 10^{-6}$ m.s^{-1}) Retained water shall infiltrate during 24 – 48 hours. Otherwise there is significant risk of overflown of the ditch in case of new event.

Dimensioning of the infiltration trench is based on the geometry of the trench according to the relationship Eq. 1. An example of a transverse profile of retention ditch is shown in Figure 11.

Grassed retention ditch as designed in the Czech Republic (Dzuráková et al., 2017)

Eq. 1

$$V = b \cdot h + m \cdot h^2 \cdot 1$$

V – volume of the trench per 1.0 m of length (m^3)
b – width of the ditch bottom (m),
h – depth of the ditch (m),
m – the slope of the slopes (–)

The volume of water that is infiltrated in the ditch can be determined according to the equation Eq. 2.

Eq. 2

$$V = K_S \cdot t \cdot S$$

V – volume of the infiltrated water (m^3)
t – time (day), usually considered 2 days
S – area of infiltration (m^2)
K_S – saturated hydraulic conductivity ($m.day^{-1}$)

Retention ditch should not be fortified. The fortification would limit infiltration ability of the soil profile. It is effective measure for soils with saturated hydraulic conductivity $K_s > 1 \cdot 10^{-6}$ $m.s^{-1}$ and a upper field slope of up to ca 6%.

To protect the ditch from siltation of soil particles, it is recommended to design a permanent grass strip with a width of at least 5 m above the ditch. This grass strip should be regularly mowed.

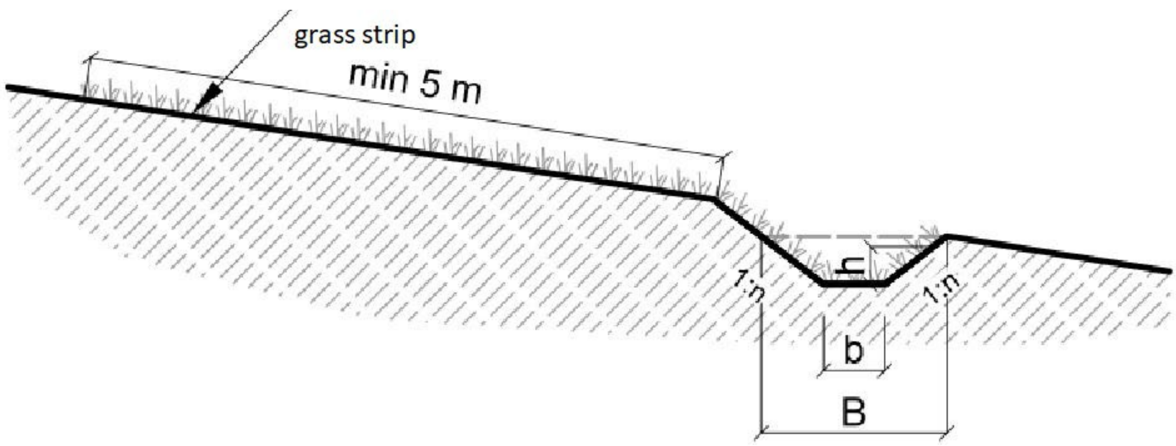


Figure 12. Transverse profile of retention ditch.

How does the strategy work in relation to the given threat?

Soil erosion

Ditches can be installed as retention an infiltration elements to interrupt long erosion prone slopes and to prevent concentrated surface runoff. The placement of a line element with a retention effect interrupts surface runoff, which decreases the intensity of erosion process in agricultural land. The effectiveness of this element in terms of retention depends on the slope of the parcel. The placement of retention ditches is recommended on parcels with a slope of up to 6%. As the slope of the parcel increases, the retention capacity of the element decreases due to its available geometry. Retention ditches can be often accompanied by other vegetation barriers and grass strips, their profile may be shallow resembling above mentioned grassed waterways and agricultural machinery can harvest it as a meadow in areas where slope steepness allows. Such an implementation is more desirable, comparing to drainage ditches, that bring a risk of speeding runoff from agricultural areas and even speeding sediment fluxes and raising sediment connectivity if not properly designed.

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

It decreases runoff, prevents soil erosion and improves moisture retention creating a favorable environment for soil microorganisms. This increased microbial activity helps improve nutrient cycling, soil structure and overall ecosystem resilience.

Soil compaction

No significant positive impact.

Soil structure

No significant positive impact.

Soil organic carbon content

No significant positive impact.

Implementation challenges

No special equipment is required to create a drainage ditch. In some cases, the use of construction machinery (e.g. an excavator) is required during construction. Maintenance of the drainage ditch requires regular inspection of the condition of the ditch. It must be ensured that it does not become blocked.

In addition, regular mowing of the grass cover and regular maintenance of the grass strip above the ditch is required.

Drainage ditches are supplemented by other objects (e.g. culverts), which must also be regularly checked and kept in good working order.

Necessary equipment and resources

To build a drainage ditch, you need to determine its location using a suitable method. The location depends primarily on the purpose for which the ditch is to be built. It also depends on a specific erosion and runoff calculation.

The design of the drainage ditch provides the necessary information about its dimensions and the required fortification.

The drainage ditch can be built manually or with the help of suitable construction machinery. For the maintenance of the ditch, you must provide means and suitable tools for mowing the grass and cleaning debris in the trench.

Pros and cons of the strategy

PROS:

- Improve the ecological stability of the site and the surrounding area through greening and possible planting of accompanying vegetation.
- Sub-species of biodiversity.
- Protection of the soil from erosion and intensive surface runoff and improvement of soil quality
- Protection of surface water from sediment and nutrient input

CONS:

- Reduction in crop yields due to the use of arable land.
- The cost of constructing the measure.
- Costs for maintenance and care.

Additional resources

https://eec.ky.gov/Environmental-Protection/Water/Protection/DocsEPSC/EPSC-DrainageDitches.pdf

BACK TO SOIL DEGRADATION PROCESS SELECTION

Drainage ditches

Description

A retention ditch is designed for draining the field from excessive water (often as a part or a drainage pipe systems). It can interrupt and trap the surface runoff and then route it into watercourses.

Implementation

Drainage ditches collect surface runoff and ensure that the water is safely diverted away from the plot. It is usually created with a longitudinal slope (1-3%). The placement of a linear element interrupts surface runoff, reducing the intensity of the erosion process on agricultural land. The effectiveness of this element in terms of retention depends on the slope of the plot. The construction of drainage ditches is used on plots with a slope of over 6%. As the slope of the plot increases, the retention capacity of the element decreases. In addition to retention ditches, drainage ditches are often accompanied by other vegetation barriers and green strips.

Drainage ditches are dimensioned/designed based on the peak runoff caused by the design rainfall. Ditches usually have a trapezoidal profile with a bottom width of 0.3 - 0.6 m (depending on the peak runoff caused by design rainfall). Slope gradients 1:1.5 - 1:2. Depth of the trench 0.6 - 1.2 m.

The periodicity of the design rainfall event depends on the potential damage to the protected structure and usually varies between 5 years (in the case of low value structures or agricultural plots), 10-50 years (in the case of normal value structures) and 100 year return period (for the protection of urban areas).

Drainage ditches must always be checked for soil and slope stability. If necessary, the base and slope must be reinforced. The type of reinforcement depends on the local conditions. As a rule, concrete blocks or semi-vegetated blocks are used in combination with grass reinforcement.

Dimensioning of the drainage ditch is based on the geometry of the ditch and peak flow caused by design rainfall according to the Chézy equation (Eq. 3). An example of a transverse profile of retention ditch is shown in Figure 14 and Figure 15.

Figure 13. A small drainage ditch as a part of drainage field system (Czech Republic).

Eq. 3

$$Q = S \cdot \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I^{\frac{1}{2}}$$

Q – discharge ($m^3.s$-1)
S – cross-sectional area of the ditch (m^2)
n – Manning's coefficient (-)
R – hydraulic radius (m)
I - slope of the trench bottom (-)

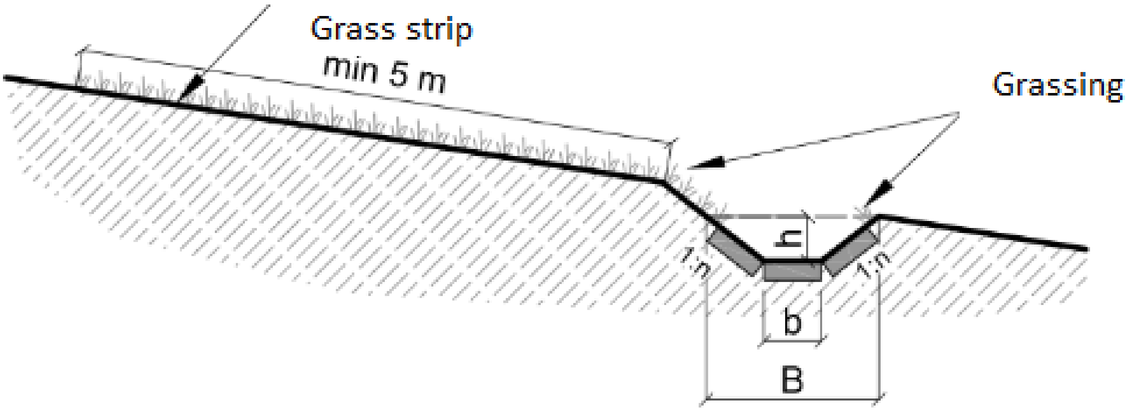


Figure 14. Transverse profile of drainage ditch with concrete blocks and grassing.

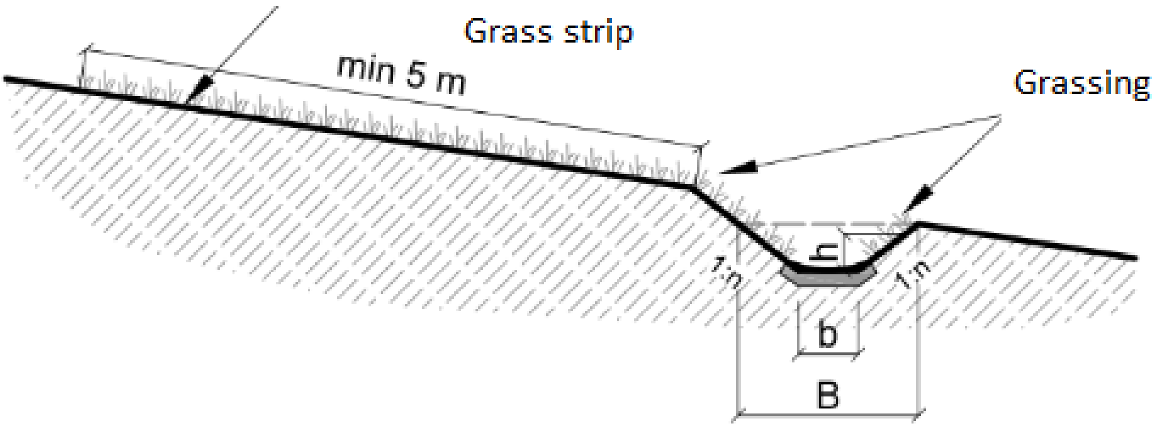


Figure 15. Transverse profile of drainage ditch with semi-vegetated blocks and grassing.

How does the strategy work in relation to the given threat?

Soil erosion

Drainage ditches allow interrupt of the surface runoff and thereby decrease the intensity of the erosion process. Ditches also capture surface runoff and divert it safely away from the affected parcel. Partial sedimentation of the eroded material has a positive effect on water protection. It can decrease sediment and bound nutrients input into watercourses.

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

No significant positive impact.

Soil compaction

Drainage ditches have no direct effect on the compaction status of the soil. However, all positive effects of erosion control and soil structure improvement ultimately also improve the soil's resilience against harmful compaction.

Soil structure

No significant positive impact.

Soil organic carbon content

No significant positive impact.

Implementation challenges

No special equipment is required to create a drainage ditch. In some cases, the use of construction machinery (e.g. an excavator) is required during construction. Maintenance of the drainage ditch requires regular inspection of the condition of the ditch. It must be ensured that it does not become blocked.

In addition, regular mowing of the grass cover and regular maintenance of the grass strip above the ditch is required.

Drainage ditches are supplemented by other objects (e.g. culverts), which must also be regularly checked and kept in good working order.

Necessary equipment and resources

To build a drainage ditch, you need to determine its location using a suitable method. The location depends primarily on the purpose for which the ditch is to be built. It also depends on a specific erosion and runoff calculation.

The design of the drainage ditch provides the necessary information about its dimensions and the required fortification.

The drainage ditch can be built manually or with the help of suitable construction machinery. For the maintenance of the ditch, you must provide means and suitable tools for mowing the grass and cleaning debris in the trench.

Pros and cons of the strategy

PROS:

- Improve the ecological stability of the site and the surrounding area through greening and possible planting of accompanying vegetation.
- Sub-species of biodiversity.
- Protection of the soil from erosion and intensive surface runoff and improvement of soil quality
- Protection of surface water from sediment and nutrient input

CONS:

- Reduction in crop yields due to the use of arable land.
- The cost of constructing the measure.
- Costs for maintenance and care.

Additional resources

https://eec.ky.gov/Environmental-Protection/Water/Protection/DocsEPSC/EPSC-DrainageDitches.pdf

BACK TO SOIL DEGRADATION PROCESS SELECTION

Fish scale pits

Description

Fish scale pits (FSPs) are often semicircular or crescent-shaped pits that are built in slopes in an alternating pattern, similar to the arrangement of the scales of a fish, and are used as a transitional measure in areas with shallow stony soils and short steep slopes for afforestation (Figure 13). The FSPs are an effective soil and water conservation measure in arid and semi-arid areas that can intercept and retain runoff, store soil moisture, reduce soil erosion, facilitate tree seedling survival and growth, maintain soil fertility. When used in practice, it often combines with other techniques like mulching, infiltration hole, and drip irrigation. Presently, the measure is widely used on the Loess Plateau and mountain areas of northern China as well as the semiarid zones of Africa. The soil and water conservation benefits of the FSPs are affected by its scale, rainfall, the slope direction and gradient, and the surface cover, etc.

Implementation

A typical FSP is composed of natural slope surface, pit and ridge (Figure 14).

The implementation of fish scale pits can take the following steps:

Determine the design standard based on local hydrometeorological conditions. Runoff depth (mm) of a five-year return period storm is commonly used on the Loess Plateau, China.

Determine the rational planting density of trees based on slope direction, gradient, soil, species and climate. This density is equivalent to the designed pit density (pits/ha).

Arrange the calculated pits in the slope by different combinations. Usually, connected arrangement, half alternate arrangement and alternate arrangement (Figure 15) were used. The connected arrangement was applicated for high-density-planted species like shrubs, and alternate arrangement was applicated for low-density-planted species like trees.

Calculate rainfall-collecting volume per pit based on total collected runoff (=runoff depth×runoff coefficient×area) and planting diversity.

Estimate the volume of earth excavation per pit according to the shape per fish scale pit (usually spherical or spherical cone shape), the pit shape with the minimum amount of earth excavation is chosen.

The recommended design code is given in the following table (Table 2).

Figure 16. Newly-built fish scale pits (left) at the Loess Plateau and fish scale pits afforested with coniferous trees in the mountain areas of north China (right).

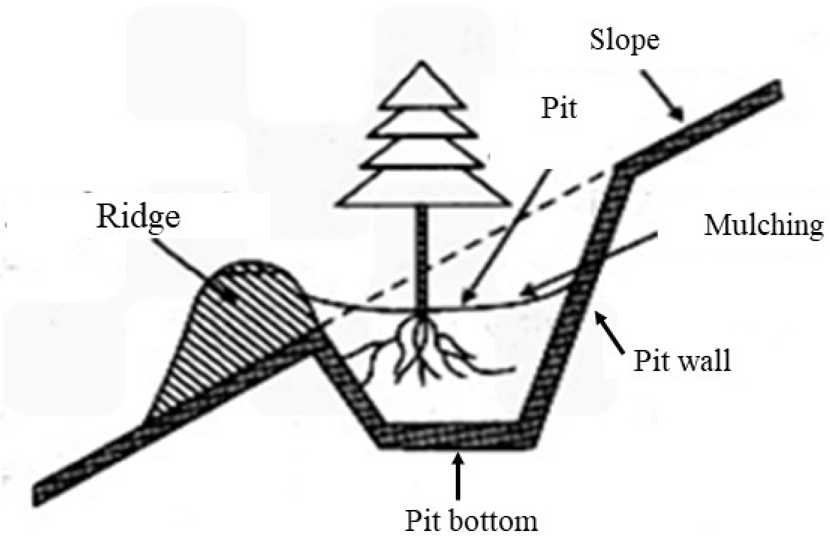
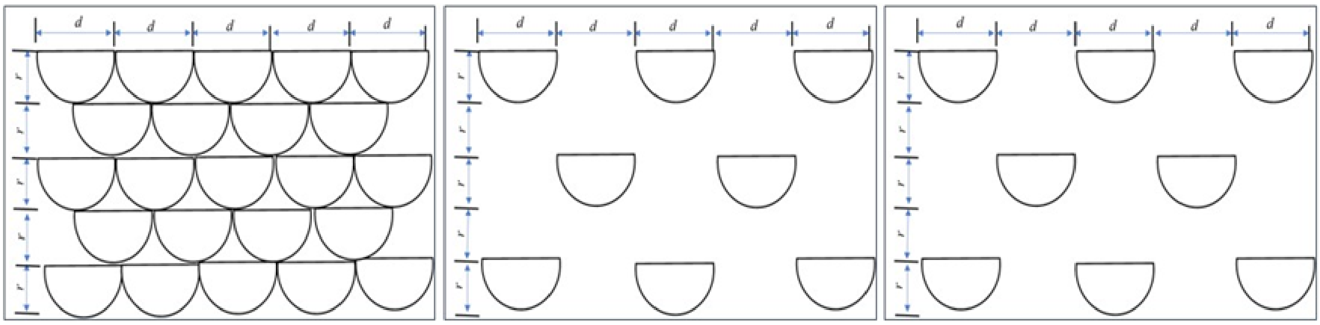


Figure 17. The section diagram of a typical fish scale pit.



a) b) c)

Figure 18. Different field arrangement of fish scale pits. (a) connected; (b) half connected; (C) alternate connected

How does the strategy work in relation to the given threat?

Soil erosion

When the rainfall intensity is small and the duration is short, the fish scale pit unlikely overflow due to the small amount of water per unit area. Therefore, it plays the role of cutting off and storing runoff in sections and pieces. When the rainfall intensity is large and the duration is long, the fish scale pit will overflow because of the large amount of water per unit area. Because the middle ridge of the fish scale pit is higher than both sides, thus the downward flow is not a straight line along a single direction, thus avoiding runoff concentrated. Slope runoff is regulated by the rows of fish scale pits, so that the scouring ability of downward runoff is weakened.

Table 2. The design code of fish scale pits.

Scale	Size	Key points	Suitable area
Large FSPs	Long diameter:1-1.5 m Small diameter:0.6-0.8 m Ridge height:0.3-0.4 m	The earth ridges are made curved in the lower part, and the ridges are high in the center and low in the two sides. Pits are laid along the contour lines in field. Inverted-octagon-shape diverted trenches are excavated at both ends of the pit with 0.2-0.3 m long.	Mild and moderate slopes with thick soil layer and dense vegetation
Small FSPs	Long diameter:0.6-0.8 m Small diameter:0.4-0.5 m Ridge height:0.2-0.3 m	The earth ridges are made curved in the lower part, and the ridges are high in the center and low in the two sides. Pits are laid along the contour lines in field. Inverted-octagon-shape diverted trenches are excavated at both ends of the pit with 0.2-0.3 m long.	Sites with fragmented slope surface and thin soil layer

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

It decreases runoff, prevents soil erosion and improves moisture retention creating a favorable environment for soil microorganisms. This increased microbial activity helps improve nutrient cycling, soil structure and overall ecosystem resilience.

Soil compaction

Fish scale pits have no direct effect on the compaction status of the soil. However, all positive effects of erosion control and soil structure improvement ultimately also improve the soil's resilience against harmful compaction.

Soil structure

No significant positive impact.

Soil organic carbon content

No significant positive impact.

Implementation challenges

Building fish scale pits is laborious, especially in steep slopes. When the heavy storms exceed the design standard, the ridges are often destroyed, so the irregular maintenance are needed.

Necessary equipment and resources

In most cases, fish scale pits are performed totally by manpower and some easy-to-get tools like shovel and digger. Machinery like excavators can be helpful for large earthwork and relatively accessible areas. For mountainous region of earth and stone, stones, bricks and/or cement are often used to build the ridges of large fish scale pits.

Pros and cons of the strategy

PROS:

- Reducing the amount and speed of surface runoff, so that soil erosion is reduced.
- Enhance soil infiltration and improve soil water storage.
- Increase the survival and preservation rate of afforestation, and improve tree growth and productivity, and the species diversity of plant communities.
- Increase soil moisture in deep layers, thus alleviate the occurrence of soil desiccation.
- Increase soil organic carbon and total N, inorganic N, capillary porosity, etc., thus improve soil quality.

CONS:
Technologically, the density of 'fish scale pits' is not easy to determine for farmers.

- The cost of construction and maintenance is large.
- Inefficiency under very dry and heavy rainstorms and on very steep slope.
- The effectiveness of the FSPs in reducing runoff was highly variable.

Additional resources

张延龄.1960. 关于鱼鳞坑水平沟等整地造林对林木生长和拦阻径流的观测分析和意见.林业科学, 2:125-131.

窦玉青.1986.鱼鳞坑的水力性质及设计指标.水土保持通报, 4:53-58.

Fu S， Liu B, Zhang G, Lu B, Ye Z. 2010. Fish-scale pits reduce runoff and sediment.Transactions of the Asabe, 53(1): 157-162

Guo H, Zhang B, Hill R L, Wu S, Dong Q, Sun L, et al. 2019. Fish-scale pit effects on erosion and water runoff dynamics when positioned on a soil slope in the Loess Plateau region, China. Land Degradation & Development, 30 (15): 1813-1827

BACK TO SOIL DEGRADATION PROCESS SELECTION

Terracing

Description

Terracing is a method of agriculture and soil conservation practiced on hills and sloping land. It was traditionally used by the Incas and is now widely practiced all over the world. The special situation is in China. Terracing can be traced back to 5000 years ago in Southeast Asia (Price a Nixon 2005). They are one of the oldest water and soil conservation techniques and are usually created in hilly and mountainous areas.

It involves building platforms that form step-like structures along a slope. Terraced fields vary in shape and size and consist of a flat section and an almost vertical slope (protected by a wall of dry stones, earth, grass or trees). Based on landforms, terraces can be divided into three types: level terraces (mostly stone-walled terraces and earth-walled terraces), alternating slope terraces (earth hedges) and slope terraces (Tang K. L. 2004).

The main aim of terracing is to regularly interrupt the slope of the land with flat sections. This helps to increase the area of the cultivable soil and to reduce the speed of water runoff, which significantly reduces soil erosion and surface runoff.

Implementation

Terracing makes it possible to use plots of land that could not otherwise be used due to the steep slope and fragmentation. There are many types of terraces in terms of technical solutions, agricultural use and morphological parameters. Terraces for agriculture are constructed by carving step-like flat areas into a hillside or slope, stabilized by retaining walls. The implementation involves surveying the land to deter-

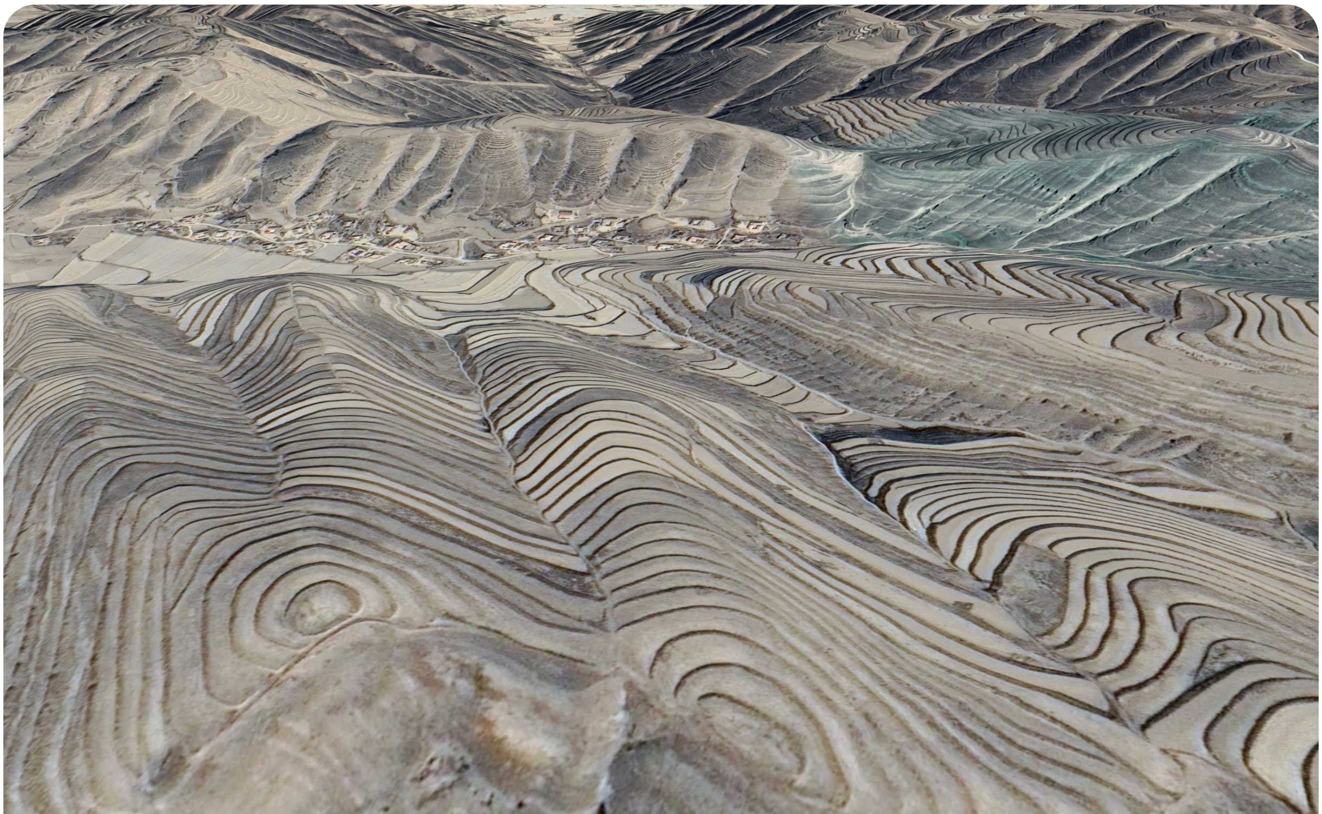


Figure 19. Terracing in Hengshan District, Yulin, China (Google Earth).

mine the appropriate contour lines, excavating soil to create level platforms, building retaining walls using materials such as stone, concrete, or wood, and ensuring proper drainage to prevent erosion. The process may also include the installation of irrigation systems to manage water distribution efficiently across the terraced fields. This practice requires careful planning and engineering to ensure stability and sustainability. You can find more information about terracing in the BMP catalogue (Goméz et al. 2021).

How does the strategy work in relation to the given threat?

Soil erosion

Reducing the slope of the parcel by terracing helps to reduce the intensity of surface runoff and subsequent erosion. Consequently, the infiltration of rainwater into the soil increases and the retention capacity of the landscape is improved. The retaining walls of terraces also help to hold soil in place, preventing it from being washed away during heavy rains. Terracing can improve ecosystem services, such as reducing runoff, controlling soil erosion, improving soil fertility, increasing crop yields, protecting habitats and biodiversity, restoring degraded habitats, etc. (Deng et al. 2021; Wei et al. 2016).

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

Terracing promotes the biological activity of the soil by reducing soil disturbance and preserving soil structure. It prevents soil erosion and improves moisture retention creating a favorable environment for soil microorganisms. This increased microbial activity helps improve nutrient cycling, soil structure and overall ecosystem resilience. Good soil structure brings balance between air, water and food for soil biota.

Soil compaction

Terracing has no direct effect on the compaction status of the soil. However, all positive effects of erosion control and soil structure improvement ultimately also improve the soil's resilience against harmful compaction.

Soil structure

Extensive excavation activities, like terracing, involve such a significant displacement of soil material that it not only degrades the soil structure but also affects most of the soil functions and properties (e.g. changes of original layering of soil horizons, extended surface erosion, compaction, loss of organic matter).

Soil organic carbon content

No significant positive impact.

Implementation challenges

Terraces involve significant labor, materials and operating costs and cause major land disturbance, especially when they are constructed on a large scale. The cultivated crops, local climate and the tools available for cultivation must be taken into account. Minimizing construction costs can be achieved by ensuring that the volume excavated and filled for the terraces is the same. It is important to compact the soil properly during backfilling (approx. every 15 cm). Terraces need regular maintenance to prevent the retaining walls from collapsing and to manage issues like waterlogging and poor drainage.

Soil overturning can lead to low soil biodiversity and fertility, so it may be necessary to supplement the soil with additional nutrient sources (Deng et al. 2021). The benefits of terracing can only be fully observed after a longer period (approx. 2 years after the terrace has been established).

Necessary equipment and resources

To successfully create terraces, you will need suitable digging equipment, equipment to mark the plot. You can also use a tractor or other machinery to push or shovel the soil (for larger projects). Stones or wood are required for the construction of retaining walls. Alternatively, the earth can also be used (for earth embankments).

Before construction, there are several factors that need to be considered depending on the local climate, the type and permeability of the soil and the intended use of the terraces. For the assessment of the local situation and the design of terraces one must:

- Plan the terraces (size and number)
    - Type of terraces
    - Length of terraces
    - Spacing of the terraces
    - Slope of "rising" (Figure 20)
        - For hand-made benches with earth material: a slope of 0.75:1
        - For hand-made benches with rocks: a slope of 0.5:1
        - For machine-built benches with earth material: a slope of 1:1
- Marking contours
- Construct the terraces.

Pros and cons of the strategy

PROS:

- Terracing can convert steep slopes into usable agricultural land, increasing the area available for cultivation.
- Reduce the speed of water runoff.
- Improve soil infiltration and water retention in the soil.
- Reduce soil erosion and surface runoff amount.
- Protect soil surface from erosion and consequently from nutrient transport, thus improving soil quality, fertility and yields.
- Terraces may lead to improved groundwater and surface waters quality.
- Enhance resilience to extreme weather events by stabilizing the soil and improving water management.
- Can create a visually appealing landscape, which can also have tourism potential in some regions.

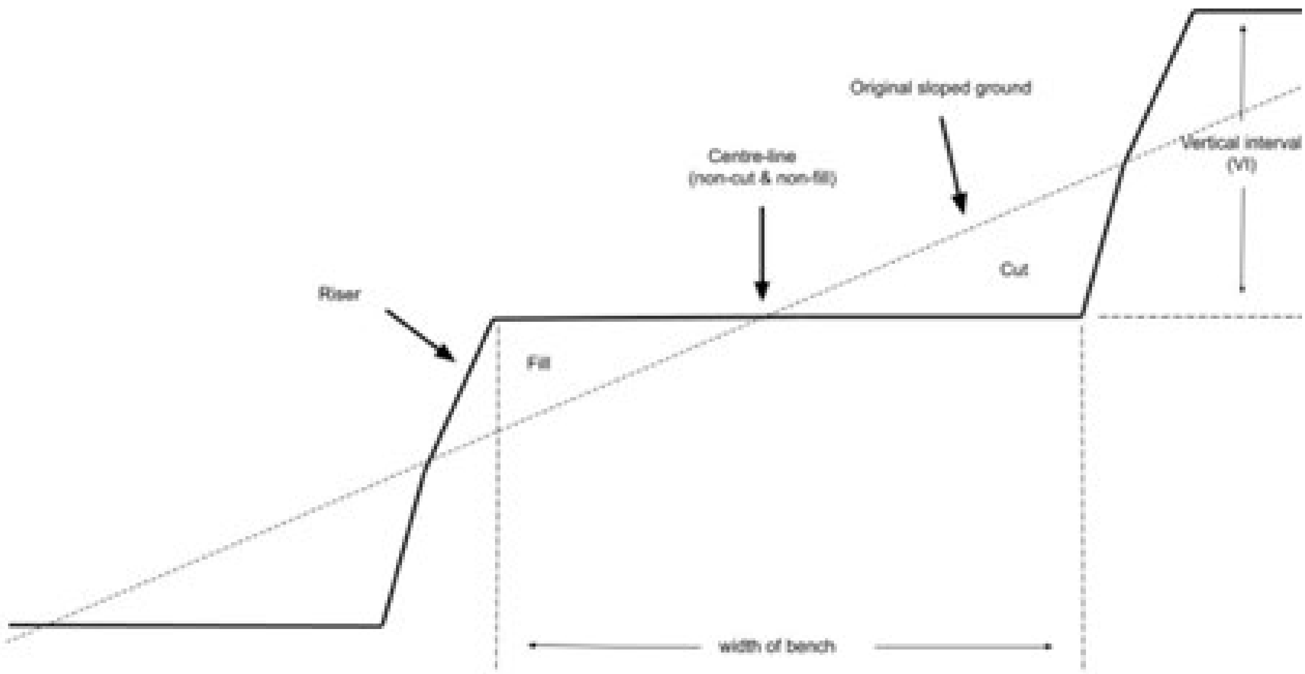


Figure 20. Cross sectional view of terrace (Mesfin et al. 2018)

CONS:

- High initial costs of the necessary equipment, labor and materials.
- Need regular maintenance to keep the retaining walls intact and to manage water flow, which can be resource intensive.
- Soil overturning can disrupt existing ecosystems, hydrology and nutrient cycle in the soil.
- The land used for constructing retaining walls and pathways can reduce the overall area available for cultivation
- Improperly designed terraces can lead to waterlogging or poor drainage, negatively affecting both soil and crop health.
- The positive effect fully appears after a longer period of time.

Additional resources

A Field Guideline on Bench Terrace Design and Construction (wordpress.com)
practice_g.terraces_final.pdf (iucn.org)

BACK TO SOIL DEGRADATION PROCESS SELECTION

Sustainable irrigation

Description

Rapid desertification in the recent past has increased the area that needs to be irrigated. Worldwide, 18% of arable land is irrigated. Statistics show that the continents most affected by the excessive irrigation are Asia, Africa and South America. As the demand for food increases, more agricultural land and irrigation is needed (Nikolaou et al. 2020). There is therefore a risk that surface and groundwater resources will be depleted.

Sustainable irrigation refers to the practice of managing water resources in agriculture in a way that balances the need for crop production with the conservation of water ecosystems. It aims to maximize the efficiency of water use and minimize the impact on the environment by using techniques that ensure water remains available for future generations without depleting natural resources or causing ecological damage. This includes methods such as deficit irrigation, the use of non-conventional water sources and the use of advanced irrigation technologies to achieve effective water management.

The least sustainable irrigation method is flooding or surface irrigation. It is used by more than 95% of farmers and is responsible for wasting up to 50% of the water supplied (Flood or Furrow Irrigation: Detailed Overview [2022] - AGRIVI). However, in some areas recent studies are reappraising surface irrigation using water derived from rivers or basins, and performed using precision agriculture criteria, due to its capacity to infiltrate water in the deep soil horizons, thus replenishing groundwater resources (Masseroni et al., 2024). Flood irrigation is less wasteful in terms of evaporation than some other methods. It is also the most energy-efficient method of irrigation.

There are two perspectives on sustainable irrigation. From the farmer's perspective, it is about securing the necessary amount of water for the crops at a profitable price. From an environmental perspective, it is about the amount of water that can be replaced naturally without compromising future water needs (Yang et al. 2023).

If we were able to switch to more efficient irrigation practices and systems, reuse treated wastewater and grow more drought-resistant crops, we could save up to 43% more water (Ahmed et al. 2022).

There are many types of irrigation systems in use today. The choice of irrigation type depends on several factors (e.g. type of crop, size of the field, cost of installation and ongoing maintenance).

Implementation

The system is generally applied in farming and landscaping activities. The system encompasses four main stages (Sustainable Irrigation Methods for Farming – Sprinkler Supply Store):

The Main Pumping Station (Intake Structure)

The water from the pumping station is directed from the main source (reservoir) to the main irrigation system. In some cases, however, the source of the irrigation water may be lower than the irrigated fields. In such a case, a pump must be used to transfer the water to the irrigation system.

Water Conveyance System

The water is distributed from the pumping station across the irrigation field. The water is fed through open channels or pipelines. The channel can either be earthed or lined (with impermeable materials). The water flowing through the channels must be controlled. Therefore, the channels are equipped with special structures that regulate the amount of flowing water.

Field Application System

Crops can be irrigated using various methods. The most important good practices of irrigation are

- Surface irrigation, performed using optimised flowrate per unit width and field geometries (border width and slope)
- Sprinkler irrigation, performed using automated systems and soil moisture sensors
- Drip irrigation - By delivering water directly to the plant roots, drip irrigation minimizes water loss due to evaporation and runoff. It is highly efficient and can be adapted to deliver nutrients together with water.
- Deficit Irrigation - This technique involves applying water below the full crop water needs, particularly during less sensitive growth stages, to reduce water use without significantly affecting yield.
- Use of Non-Conventional Water Sources - Farmers may use treated wastewater or captured rainwater for irrigation, reducing dependency on freshwater sources.
- Weather monitoring to implement a soil water balance, Soil Moisture Sensors and Automation - Implementing advanced sensors can help in applying water only when necessary. Automation of irrigation systems based on real-time data can optimize water use. These systems can be applied to all water delivery methods
- Crop Selection and Rotation - Choosing crops that are suitable for the local climate and soil conditions, or rotating crops with different water needs, can enhance the sustainability of water resources.
- Mulching and Cover Crops - These practices help in retaining soil moisture and reducing evaporation, thus lowering the water needed for irrigation.

Drainage system

The drainage system is used to remove excess water from the field.

How does the strategy work in relation to the given threat?

Soil erosion

Adequate and sustainable irrigation ensures optimal soil moisture, both for plant growth and for the quality of the soil itself. A soil with optimum moisture does not form a dry surface with a crust, it is more cohesive and consequently more resistant to the effects of rainfall and surface runoff. Techniques like drip irrigation deliver water directly to the root zone, minimizing the force of water on the soil surface, thereby reducing surface runoff and the potential for erosion.

Fertilizers / nutrient balance

Irrigation has an impact of fertiliser requirements, as it influences the plant growth rate and yield. Irrigation performed in excess can also increase leaching losses that amplify the environmental losses and reduce the availability of N. These items could affect the plant nutrient requirements.

Biological activity

Sustainable irrigation results in an increased amount of organic matter that increases the biomass of soil biota. It also decreases soil compaction which creates a greater number of micro and macro pores providing living space for a diverse composition of soil fauna. Good soil structure brings balance between air, water and food for soil biota. The negative effects of salinization brought about by irrigation also decreases positively affecting the composition and abundance of soil microbial community composition particularly the bacterial communities.

Soil compaction

Sustainable irrigation has no direct effect on the compaction status of the soil. However, any positive effects due to reduced erosion and soil structure improvement by enhances root growth also improve the soil's resilience against harmful compaction.

Soil structure

Long-term irrigation may affect mostly soil structure, compaction, clay dispersion, surface crusting, and secondary salt accumulation. The stability of the structure is more dependent on the applied intensity of the irrigation. Sustainable irrigation preserves soil structure and porosity and allows water to move through the interconnected pore system, avoiding ponding.

Soil organic carbon content

Irrigated agriculture increases SOC stocks by 5.9%, with differences varying by climate and soil depth. The greatest increase in SOC is observed on irrigated semi-arid sites at the 0–10 cm depth (14.8%), and in fine- and medium-textured soils. The distribution method seems to be influent also, with sprinkler irrigation allowing a better SOC increase than surface or drip systems (Emde et al. 2021).

Implementation challenges

There are currently three main types of irrigation systems, which differ in terms of their characteristics, the equipment required, their efficiency and their suitability for use in different conditions.

Surface Irrigation

It depends on gravity to distribute the water to the fields through channels. Surface irrigation is ideal for orchards, field crops and pastures. Surface irrigation is considered less effective compared to sprinklers and drip irrigation. The efficiency of surface irrigation depends on various factors (soil type, topography of the field, type of crops grown, cultivation methods).

Sprinkler Irrigation

The water is sprayed or sprinkled onto the field. The water is fed into the system under pressure via underground pipes. The sprinkler irrigation system is used for various crops, including lawns, vegetables, field crops, orchards, pastures, etc. The system is also used to protect plants from frost. Sprinkler irrigation systems control water more efficiently than surface irrigation but can be negatively affected by wind.

Micro-irrigation

An irrigation system that distributes water at low intensity and pressure to the plants at exactly defined locations. Water drips from small holes in pipes to moisten a desired spot on the ground. Micro-irrigation is ideal for watering trees, shrubs and vineyards. The risk with this system is the build-up of salts in the pipes. For this reason, attention is paid to the optimum chemical composition of the water, which makes the system more expensive.

General challenges include initial investments for advanced irrigation systems or automated technology, specific technical knowledge and specialized skills for installation, operation and maintenance are needed.

Necessary equipment and resources

The equipment needed to implement sustainable irrigation systems varies depending on the method used, but generally includes several key components. First, a reliable source of irrigation water is essential, whether it comes from conventional sources such as rivers and groundwater or from non-conventional sources such as recycled wastewater or captured rainwater. Transporting this water from the source to the fields usually requires infrastructure such as pumps to lift it and pipes or canals to convey it, especially if the source is not gravity-fed. In the field, the distribution system can range from highly efficient drip or micro-sprinkler systems, which deliver water directly to the plant roots, to conventional sprinkler systems or surface irrigation systems. In addition, proper drainage systems are critical to manage runoff water and prevent waterlogging so that excess water can be efficiently removed from the field. Together, these components form a cohesive irrigation system that not only optimizes water use, but also supports the sustainability goals of minimizing waste and reducing environmental impact.

Pros and cons of the strategy

PROS

- Reduced water usage
- Long-term cost savings
- Increases crop yields an improves its quality
- Helps to ensure food security
- Minimizes runoff and leaching, reducing water pollution and protecting local waterways and ecosystems

CONS

- High initial investments of the necessary equipment
- Cost for maintenance and service
- Fuel/electricity consumption
- Dependency on technologies

Additional resources

finalwater 00 05 checked.PDF (saiplatform.org)

BACK TO SOIL DEGRADATION PROCESS SELECTION

Organic fertilization

Description

Organic fertilisation includes the distribution of plant-based or animal-based degradable products to supply plant nutrient demands. The most widely used materials are animal manures (solid or liquid), digestate (liquid) and composted plant debris (solid). These organic fertilisers are normally produced in the farm, or in a neighbour farm, as their high-water content makes transportation rather expensive.

Commercial products also exist, mainly as dried materials, but the high cost makes their use in the open field limited to specific conditions.

Implementation

Livestock farms produce solid and/or liquid manures that can be distributed on farm soils using specific machinery. The distribution can also be made by specific companies that can afford the cost of high technology machineries that implement immediate incorporation of the manures (to reduce NH_3 volatilisation), ensure low pressure on soil, and even measure the manure nutrient content using an infrared technology, for precision fertilisation.

Commercial organic fertilisers are generally in the for of pellets, and their cost is high due to the cost of transportation and drying processes. In some cases, the nutrient content of manures is modified by the addition of extra nutrients in a mineral for, thus constituting organo-mineral fertilisers.

How does the strategy work in relation to the given threat?

Soil erosion

Organic fertilization increases the content of organic material in the soil. Organic material provides soil cohesion. As a result of organic fertilization, the soil is more resistant to precipitation and surface runoff, and subsequently more resistant to erosion.

Fertilizers / nutrient balance

Organic fertilisers pose some problems to the calculation of the fertiliser supply. A first problem lies in the great heterogeneity of the organic matrices, that change with time (as it changes with maturation), animal type (species, age, diet, bedding material…) and management (storage condition and length…). Sedimentation in the distribution tank adds another source of variation. Consequently, the nutrient concentration of manures is far from being standardisable.

In addition, only part of the nutrients contained are easily available, that means that they can be used by the subsequent crop. Part of N, in particular, is in the mineral form, mainly NH_4^+, and can be quickly used by the crop. Another part is available to the crop after a mineralisation process, that requires some time. Ideally, the mineralisation should be synchronised with the plant uptake, otherwise losses can occur (Zavattaro et al. 2012). The mineralisation provides some delay that can be positive, as it provides a slow-release that can increase the plant use efficiency. In addition, another part of N is contained in organic recalcitrant molecules, and the time to decompose them can be longer than one year (Webb et al.

2013). This legacy of N supply is typical of solid manures with a high C:N ratio, and is generally longer if the manure is spread not regularly, i.e. not every year at a single field.

Conversely, P in manures is generally more easily available than the corresponding amount in mineral fertilisers (Battisti et al. 2022). Potassium is normally considered as totally and immediately available to crops.

Biological activity

Organic fertilizers are additional direct food source for soil decomposer communities, enhancing their biomass and density. Organic fertilizers increase the above and belowground biomass of plants which indirectly increases the abundance and composition of soil biota. Adding organic matter to the soil enhances soil structure and increases the number of macropores which support the presents of mezzo and macro organisms in the soil.

Soil compaction

Organic fertilizing may have a positive effect regarding soil compaction. The application of accurately dosed organic fertilizer supports humus accumulation and a very active soil life, which significantly improves the soil structure and thus increases resilience against soil compaction.

Soil structure

Crop rotation and manure application are the most common agricultural practices that reportedly improve soil physicochemical properties (Fu et al. 2022). As a result of a mid-term experiment on clayey soil, additional cover crop inclusion in a crop rotation improved the hydraulic properties and significantly enhanced soil water retention after 5 years (Çerçioğlu et al. 2019). The different rooting depths of crops grown in rotation help to develop and maintain topsoil structure.

Soil organic carbon content

Application of organic fertilizers increases the organic carbon content of the soil and generally improves soil structure and consequently the physical, chemical, and biological properties of the soil (Gliński et al. 2011; Szajdak et al. 2014). How does the strategy work in relation to the organic carbon content. Organic fertilisers, and manures in particular, are the most effective way to increase the soil C content. More than 30% increase of SOC is expected after long-term distribution of solid manure, and 17% increase using bovine slurry, compared to a similar mineral fertilisation (Zavattaro et al. 2017). Dămătîrcă et al. (2023) showed that manuring increased both the fraction of SOM occluded into aggregates (oPOM) and mineral-associated (MAOM), not only in the tilled layer but also in subsoil. Therefore, the increase of SOM that can be obtained through sustainable irrigation is large and also relevant, as most of the stored soil C is in the most stable MAOM form.

Figure 21.

Implementation challenges

Manure is produced by animals; therefore, a good spatial integration of livestock and non-livestock farms should be obtained in order to ensure a good use of manures in all type of farms. Otherwise, non-livestock farms can rely on plant-based compost, or purchased organic fertilisers.

As the N:P ratio of manures is different from that of crops, manure composition is generally not well balanced and provides an excess of P to soil, with consequent overload in the long term. A challenge is to plan animals' diet more carefully, thus reducing the amount of nutrients excreted and also balancing the N:P ratio to obtain a by-product with a higher agronomical value.

Necessary equipment and resources

Organic fertilisers can be liquid or solid. Depending on the status, different machinery is needed.

Special machinery can distribute liquid manure close to the soil surface (trailing shoes) or injection below the soil surface in a furrow, even in grassland (see Figure 17). The spreading through splash plate, although more economic and often quicker, should be avoided because of the high NH3 volatilisation losses (it is in fact forbidden in some European countries). Manures should be incorporated very soon after distribution, within 2 hours, as NH3 volatilisation losses mainly occur during and just after distribution.

Owing to the large variability of slurry composition, some spreading systems include a NIRS technology for NPK rapid analysis and a variable-rate distributor, for a precision fertilisation approach.

Pros and cons of the strategy

PROS:

- Saving of mineral fertilisers (saving of money and environmental impact of fertiliser production)
- SOM increase
- Soil life stimulation
- Recycle of nutrients within a farm

CONS:

- High cost for distribution
- Unevenness of distribution of nutrients across the field
- Uncertainty in nutrient content
- Low nutrient use efficiency in winter crops

Additional resources

Microsoft Word - SE-V1N1-p54.doc (core.ac.uk)
Guidelines for Organic Fertilization | Center for Agriculture, Food, and the Environment (umass.edu)
(17) (PDF) Organic Fertilizers: Types, Production and Environmental Impact (researchgate.net)

BACK TO SOIL DEGRADATION PROCESS SELECTION

Planning traffic frequency

Description

Driving on the soil with heavy agricultural equipment under unfavourable conditions (when the soil is close to its plastic limit, when it is wet) should be avoided. This also includes reducing the annual traffic frequency.

Traffic frequency planning is an important agricultural protection measure to reduce soil degradation caused by machine movements. Excessive and uncontrolled traffic on agricultural fields leads to soil compaction, accelerated water runoff, increased soil erosion and damage to soil structure. These negative effects reduce soil fertility, hinder root growth and reduce crop yields. By systematically controlling and limiting the number of machine passes, farmers can significantly reduce these harmful effects. This practise not only preserves soil health, but also improves water infiltration and retention, promoting more sustainable agricultural production.

Implementing controlled traffic farming involves strategic planning to minimise unnecessary travel across the field, often through the use of pre-defined tracks or zones for machine movement. This approach concentrates compaction in specific areas while leaving the majority of the soil profile uncompacted and conducive to healthy plant growth. The benefits of this practise go beyond soil conservation to include improved operational efficiency and reduced fuel consumption. As an integral part of soil improvement measures, traffic frequency planning emphasises the importance of thoughtful and precise field management to ensure long-term agricultural sustainability and productivity.

Implementation

Implementing traffic frequency in agriculture requires strategic planning and the use of specific technologies to minimise soil compaction and reduce the number of machine passes. The process starts with mapping the field and planning efficient machine routes to minimise the total area. The use of GPS technology enables precise and repeatable tracks, ensuring that the machines follow the same path every time. Controlled Traffic Farming (CTF) systems are crucial. They require machines to be aligned so that all equipment follows the same wheel tracks. This may require adjustments to existing machines or investment in new machines designed for CTF.

Figure 22. Harmful soil compaction at the headland of a field in Strengberg, Austria (© Thomas Weninger).

Minimising the number of passes is also critical to reducing soil compaction. Management strategies such as no-till significantly reduce the need for frequent machine movements, which preserves soil structure and reduces erosion. Regular monitoring and adjustments are crucial to the success of planning the frequency of travel. Farmers need to be alert to signs of compaction and erosion and make the necessary changes to the machine set-up. Training farmers on CTF techniques ensures consistent and effective implementation. By applying these practises, farmers can reduce soil compaction, improve soil structure and minimise erosion, leading to more sustainable and productive farming systems.

How does the strategy work in relation to the given threat?

Soil erosion

Planning traffic frequency helps to reduce soil erosion by minimising soil compaction and maintaining a better soil structure. Controlled cultivation restricts the movement of machinery to specific areas, reducing overall soil disturbance. This practise improves water infiltration and reduces surface runoff, which are key factors in preventing soil erosion. By concentrating compaction in certain zones, the rest of the field retains its natural porosity and stability, reducing the likelihood of soil particles being washed away during rain or irrigation.

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

Traffic directly can affect soil biota on and under the soil surface by trampling and rolling over and destroying the flora and fauna. There are a number of indirect effects as well influencing soil life under traffic. Soil compaction is one of the most influential factor. During traffic soil pores would collapse starting with the largest where larger size soil animals live and ending with the micro pores which are inhabited by bacteria. Soil compaction also restricts the transport of water through the soil. This under dry soils conditions would cause water deficit and soil erosion, limiting plant growth and soil biodiversity. Under wet soils oxygen would become a limiting factor for many soil fauna particularly for invertebrates. By planning traffic frequency and controlling traffic the impact of both direct and indirect effects can be reduced.

Soil compaction

The prevention of harmful soil compaction bases on two pillars. First, proper soil management fosters microbial activity and establishes a stable and elastic soil structure, which makes the soil resilient to external forces. Second, good farm management prevents harmful pressure by farming vehicles, particularly under wet soil conditions. The planning of traffic frequency can contribute to reduce external forces leading to harmful soil compaction across the profile.

Soil structure

Intensive traffic and heavy machinery cause mechanical compaction and structural degradation of soils, resulting temporal water logging on the surface, parallel with increasing bulk density and reducing porosity in most soils.

Soil organic carbon content

By reducing soil compaction and minimising soil disturbance, techniques such as CTF promote better root growth and decomposition of organic matter, which can increase soil organic carbon levels over time. Studies have shown that the improved soil structure and reduced erosion from CTF techniques contribute to increased soil carbon sequestration.

Implementation challenges

Some of the biggest challenges in implementing traffic frequency planning include the initial investment in technology and equipment, the need for accurate field mapping and the ongoing need for monitoring and adaptation. GPS-guided systems and machinery modifications can be costly and present a financial barrier for some farmers. In addition, the complexity of planning efficient routes and aligning machinery to follow the same tracks requires careful management and technical expertise. Another major challenge is the integration of different farming methods that minimise the number of passes, such as conservation tillage, no-till and direct seeding, which reduce the need for frequent machine movements compared to conventional methods. Farmers must also commit to regular field assessments to recognise and eliminate signs of soil compaction or erosion to ensure the effectiveness of the controlled traffic system. In addition, educating and training farmers in these new practises is crucial, but can be time consuming.

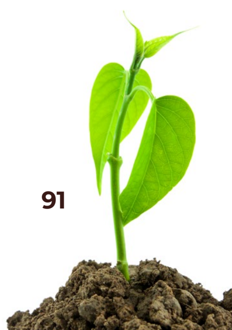
Necessary equipment and resources

To successfully implement traffic frequency planning, farmers need several important devices and resources. A GPS-guided system is critical for creating accurate, repeatable tracks for machinery to ensure consistent adherence to designated lanes. In addition, machines may need to be modified or upgraded to comply with Controlled Traffic Farming (CTF) principles, which requires adjusting wheel spacing or using machines with adjustable tracks. Farmers should also have access to field mapping tools and software for efficient route planning and management. Apart from technology, adequate training and education of farmers is required to ensure proper implementation and maintenance of the system. Regular monitoring activities, such as measuring soil compaction, are also important to assess the effectiveness of traffic frequency planning and make the necessary adjustments to optimise soil health and productivity.

Pros and cons of the strategy

PROS

- Limits soil compaction to specific tracks and preserves the overall soil structure.
- Improves water absorption and reduces runoff, which benefits plant hydration.
- Reduced soil disturbance prevents erosion and loss of topsoil.
- Better soil conditions promote healthier root development and stronger plants.



- Optimized machine movement reduces fuel consumption and operating costs.

CONS

- High costs for GPS systems and machine modifications can be an obstacle.
- Requires detailed field mapping and precise management, which can be time consuming.
- Farmers need proper training to effectively use and maintain the system.
- Existing machinery may need to be significantly adapted or replaced to make it suitable for controlled traffic systems.
- Regular field assessments are necessary to ensure the effectiveness of the system and to make any necessary adjustments.

Additional resources

https://agricology.co.uk/resource/controlled-traffic-farming/
https://www.agric.wa.gov.au/soil-compaction/developing-controlled-traffic-tramline-farming-system
https://www.nrcs.usda.gov/sites/default/files/2022-10/8023_Agronomy%20Technical%20Note%201.pdf

BACK TO SOIL DEGRADATION PROCESS SELECTION

Heavy traffic control

Description

Normal field management inevitably leads to a certain degree of soil compaction and thus to negative effects on crop production (due to reduced water infiltration and rooting restriction) and accelerated soil degradation (soil erosion, soil compaction, soil structure damage). As the size of vehicles has increased, so has their ability to damage the soil. This damage can manifest itself visibly as surface soil deformation or remain hidden beneath the soil surface. Controlling traffic in the field by minimizing the weight of machinery and loads, using the same paths for all operations (drive aisles), adjusting (reducing) tyre pressure, and reducing headland by turning on paved roads should reduce soil compaction.

Figure 23. Heavy machinery in Olive orchard, Spain (Gema Guzman).

Implementation

Eliminating the impact of vehicle traffic on agricultural crop production is not possible because field operations require the movement of vehicles through the fields. However, there are several strategies to minimise soil degradation caused by heavy traffic. One important approach is to reduce the axle load by reducing the size of the vehicles. This reduces the potential for deep subsoil compaction, which is often permanent and more problematic than surface compaction. The use of radial tyres is also recommended, which increase ground contact area and traction while reducing soil compaction. Lower tyre pressure, as usually recommended in the manufacturer's tyre pressure tables, also helps to reduce soil damage.

Using dual tyres or increasing the tyre size can spread the load over a larger ground area. Tracked vehicles, which are known to improve traction efficiency and reduce soil compaction, are another effective alternative. It has also been suggested to increase the speed of the vehicles to reduce soil compaction.

Managing soil moisture by ensuring it is less than 60% of field capacity before vehicle traffic can significantly improve soil strength and reduce the risk of compaction. The use of conservation tillage systems, which minimise the need for frequent passes and encourage the build-up of organic matter in the soil, also helps to reduce soil compaction. Controlled traffic systems restrict vehicle traffic to specific lanes, preventing vehicles from driving indiscriminately across fields and further minimising soil damage.

If soil compaction does occur, tilling as deep as possible can relieve the compacted layers. The tillage system chosen should disturb the soil surface as little as possible, retain extensive crop residues and be centred on the crop growth zone. Finally, natural drying and wetting cycles can positively influence soil compaction over time.

How does the strategy work in relation to the given threat?

Soil erosion

No significant direct impact. Indirectly, the heavy traffic control leads to better soil condition and decreased soil compaction. The soil is consequently more resistant to soil erosion.

Fertilizers / nutrient balance

No significant positive impact.

Biological activity

Heavy traffic directly can affect soil biota on and under the soil surface by trampling and rolling over and destroying the flora and fauna. There are a number of indirect effects influencing soil life under heavy traffic. Soil compaction is one of the most influential factor. During heavy traffic soil pores would collapse starting with the largest where larger size soil animals live and ending with the micro pores which are inhabited by bacteria. Soil compaction also restricts the transport of water through the soil. This under dry soils conditions would cause water deficit and soil erosion, limiting plant growth and soil biodiversity. Under wet soils oxygen would become a limiting factor for many soils fauna particularly for invertebrates. By controlling heavy traffic the impact of both direct and indirect effects can be reduced.

Soil compaction

Heavy traffic control aims to confine machinery loads to the least possible area of permanent traffic lanes. Consequently, the area of compacted land can be efficiently reduced. For the area between the fixed track lanes, this means improved soil porosity, thus improved water infiltration etc. As this technique also improves field access when soil moisture is high, there is the danger that the field is also trafficked at high soil moisture conditions. Furthermore, the reduction of compacted area should not make all efforts to avoid compaction (reduce machinery weight, cover cropping, …) appear obsolete.

Soil structure

No significant positive impact.

Soil organic carbon content

No significant positive impact.

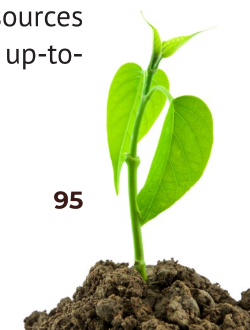
Implementation challenges

The implementation of techniques to mitigate the negative impact of heavy traffic on the soil faces several major challenges. From an economic perspective, the initial investment for equipment such as radial tyres, tracked vehicles and subsoilers can be significant. In addition, the introduction of new technologies and methods requires training and education. This process can be resource and time consuming, disrupt familiar processes and lead to temporary loss of productivity during the adaptation phase.

In practise, it is a challenge to manage soil moisture to keep it below 60% of field capacity, especially in regions with unpredictable rainfall patterns. Furthermore, field-specific adaptations are required as soil types, crop types and local conditions are very different and require customised solutions. The introduction of controlled traffic systems requires the remodelling of fields and the establishment of designated lanes, which can be logistically complex and require additional investment in infrastructure. Furthermore, the integration of advanced technologies, such as automated guidance systems, requires access to satellite technology and precision agriculture tools that are not readily available or affordable to all farmers, especially small farms. Another major challenge is overcoming resistance from farmers who are used to traditional methods, which emphasises the need to demonstrate the long-term benefits and provide ongoing support.

Necessary equipment and resources

To mitigate the negative effects of heavy traffic on soil conditions, important equipment such as radial tyres, tracked vehicles, subsoilers, dual tyres, automatic steering systems and soil moisture sensors are required. Radial tyres and tracked vehicles reduce soil compaction by increasing the soil contact area, while subsoilers remove compacted layers with minimal surface disturbance. Dual tyres help distribute weight over a larger area and automatic steering systems with satellite technology enable controlled traffic systems. Soil moisture sensors are essential for monitoring moisture levels. The necessary resources include financial investment, training and education programmes, technical support and access to up-to-date weather and soil data.



Pros and cons of the strategy

PROS:

- Implementing these strategies improves the structure and health of the soil and makes it more resistant to compaction and other stress factors.
- Reduced soil compaction leads to better water infiltration and reduced runoff, improving environmental quality.
- Over time, improved soil conditions can lead to more stable and potentially higher crop yields.
- Reduced need for frequent and deep tillage.

CONS:

- Farmers need to acquire new knowledge and skills to use these techniques effectively, which can be time-consuming and difficult.
- Significant upfront costs for new machinery and technologies, such as radial tyres, tracked vehicles and soil moisture sensors.
- Crop yields may not be affected immediately, and in some cases could temporarily decrease during the transition period.
- Existing cropping processes and field layouts may need to be significantly altered.
- Monitoring of soil conditions and maintenance of equipment can be resource intensive and demanding.

Additional resources

https://www.sare.org/publications/building-soils-for-better-crops/compaction/
https://www.multiquip.com/multiquip/pdfs/Soil_Compaction_Handbook_low_res_0212_DataId_59525_Version_1.pdf
https://defrafarming.blog.gov.uk/sustainable-farming-incentive-pilot-guidance-remove-soil-compaction/

BACK TO SOIL DEGRADATION PROCESS SELECTION

Grazing management

Description

Grazing is an activity in which herbivorous animals, such as sheep, goats, cows, and others, consume predominantly herbaceous forage in a grazing land-such as permanent and temporary grasslands and agro-silvo-pastoral systems. Grazers are allowed to move freely within a designated area to feed on the available vegetation. Grazing animals can consume a wide variety of plants, including grasses, herbs, shrubs, and in some cases, even young trees. Grazing can be an important tool for grassland management and biodiversity conservation in natural ecosystems, as long as it is carried out sustainably and considers the balance between animal feeding and ecosystem health.

Implementation

In its most basic form, grazing involves allowing animals to feed naturally in open areas where there is grass and other edible plants. However, grazing can also be managed more carefully, with measures such as pasture rotation, where animals are periodically moved to different areas to allow vegetation to recover, and grazing intensity is adjusted according to ecosystem needs.

However, it is important to note that grazing must be carefully and strategically managed to avoid negative impacts, such as overgrazing, undergrazing, soil compaction, or habitat degradation. Grazing rotation, soil health monitoring, and integration of grazing with other land management practices can help maximize the benefits of sustainable grazing.

Figure 24. Grazing with sheep in an oak Dehesa at Southern Spain. Author of photo: Gema Guzman.

How does the strategy work in relation to the given threat?

Soil erosion

Soil erosion, in the context of grazers like livestock, refers to the process where the soil is disrupted due to the impact of grazing animals' hooves and their activities. The impact of livestock trampling on grasslands varies depending on local factors such as soil type, moisture levels, types of vegetation and animals, and grazing patterns. The effects of trampling on soil erosion are heavily influenced by management practices. Properly managed grazing can improve soil aeration, redistribute nutrients, promote seed germination, and enhance soil structure, thereby reducing erosion risks. However, excessive trampling can exacerbate soil erosion. Effective grazing management is crucial for achieving positive outcomes and mitigating negative effects on soil erosion.

Fertilizers / nutrient balance

Grazing has a significant impact on the distribution of nutrients within ecosystems. As livestock consume vegetation, they metabolize nutrients and deposit organic matter through excrement, which in turn decomposes and returns nutrients to the soil. This process leads to the redistribution of nutrients across the landscape, influencing soil fertility, plant productivity, and biodiversity. However, if grazing animals are not managed prudently, negative effects related to nutrient distribution can occur. For example, in resting areas, these nutrients can be deposited excessively, leading to the growth of nitrophilous vegetation that has little or no fodder value and a drastic reduction in biodiversity.

Biological activity

Grazing significantly alters vegetation composition and structure, directly impacting biodiversity. When grazing management is carefully applied, the intake of plant species is balanced, leading to an increase in plant diversity, which in turn, supports a wider range of insect life, crucial for pollination and as a food source for many small vertebrates and birds. If the management is not well applied, grazing animals often prefer certain plants, leading to the overconsumption of these species and the proliferation of less palatable ones. This selective feeding changes the landscape, often resulting in fewer plant species and simpler vegetation structures. In general, a careful management of grazing can be used strategically to shape habitats in ways that support a broad array of plant and animal species. By carefully controlling where and how animals graze, farmers can create a balance between open areas and shrubby or wooded sections. This balance is crucial for maintaining ecosystem diversity. For example, maintaining a proper proportion of open grasslands and shrub-encroached areas can provide ideal conditions for many wildlife species. Open areas might be preferred by certain grazing animals and ground-nesting birds, which benefit from the visibility and the grasses as a food source. In contrast, shrubby areas offer critical shelter and foraging opportunities for small mammals, as well as a variety of bird species that rely on these denser portions of the habitat for protection and nesting.

Grazing on soil organisms can have both positive and negative effects. Over grazing has the most negative impact on soil organisms. Trampling, soil compaction, denudation, resource competition and anthelminthic residues in faces are the most damaging factors. Soil pores would collapse starting with the largest where larger size soil animals live and ending with the micro pores which are inhabited by bacteria. Soil compaction also restricts the transport of water through the soil. This under dry soils conditions would cause water deficit and soil erosion, limiting plant growth and soil biodiversity. Under wet soils oxygen would become a limiting factor for many soil fauna particularly for invertebrates. Anthelminthic residues have a negative effect on the number and development of beetle larvae. Defoliation stimulate plant regrowth as well as the increase in root exudation which increases the growth of microorganizms and the abundance of soil biota.

Soil compaction

Grazing has positive and negative effects regarding soil compaction. On the one hand, high surface pressures by hooves may lead to severe soil compaction in the upper soil layers, particularly under wet soil conditions. On the other hand, grassland without tillage operations and with application of manure provides a very active soil life, which significantly improves the soil structure and thus increases resilience against soil compaction. Thus, a proper grazing management has a positive impact to the soil structure.

Soil compaction reduces porosity and the soil's ability to absorb water, increasing surface runoff and water erosion. Soil compaction is a significant problem in grazing areas, primarily caused by the pressure exerted on the soil from animal trampling. As grazing animals, particularly larger ones like cattle, move and feed across the land, their hooves compress the soil. This pressure is exacerbated when animals repeatedly use the same areas or when the soil is wet, as it is more susceptible to compaction. Additionally, high stocking densities – where too many animals are grazing in too small an area – significantly increase the risk of soil compaction.

Soil structure

Soil structure degradation is another critical issue often observed in grazing areas, especially in the overgrazed ones. Trampling lead to the breakdown of soil aggregates, which are essential for maintaining soil porosity and allowing for adequate air and water infiltration. This disturbance weakens the soil's ability to resist erosion and reduces its capacity to support healthy plant growth. This can be particularly problematic in fragile soils or those with steep slopes. These physical changes in the soil, in turn, can influence the diversity and activity of soil organisms such as bacteria, fungi, nematodes, and other microorganisms. Poor soil structure compromises ecosystem resilience and productivity, highlighting the importance of implementing sustainable grazing practices to preserve soil health and functionality in grazing environments.

Soil organic carbon content

Overgrazing can result in the loss of vegetation cover, leading to a decrease in the amount of organic matter incorporated into the soil (aboveground biomass). However, if the grazing management is appropriate, the animals provide an important input of organic matter through their excrements. Such excrements are an important source of organic matter and nutrients, including carbon, and can contribute to an increase in soil organic carbon content if it decomposes and is effectively incorporated into the soil profile.

Implementation challenges

One of the major challenges is finding the right balance in grazing management. This involves determining the appropriate stocking rate for a given area, implementing grazing rotation strategies, and establishing rest periods to allow vegetation recovery. Inadequate grazing management can lead to soil degradation and loss of biodiversity.

It is crucial to minimize the negative environmental impacts of grazing, such as soil erosion, soil compaction, water pollution, and loss of biodiversity. This requires implementing grazing practices that are compatible with the conservation of ecosystems and the environmental services they provide.

The sustainability of grazing systems, essential for preserving biodiversity, soil health, and landscapes, relies on management actions based of the principle of balancing animal stocking rates with the carrying capacity of grasslands. The stocking rate has been defined as the relationship between the number of animals and the total area of the land in one or more units utilized over a specified time, whereas the carrying capacity of grasslands as the maximum stocking rate achieving a target level of animal performance, which can be applied over a defined period without grazing land deterioration. When the number of grazing animals exceeds the vegetation carrying capacity, problems of overgrazing arise. Conversely, when the number of grazing animals is below the vegetation carrying capacity, the resulting issues are related to undergrazing. Implementing rotational grazing systems (RGS) represents the most effective and straightforward approach to achieve the balance between stocking rate and the vegetation carrying capacity. In RGS, pastures are divided into paddocks, which are then grazed in rotation. To ensure optimal grazing distribution and prevent both overgrazing and undergrazing, it is crucial to incorporate attractive points such as water troughs and salt licks strategically across grazing areas. These points lure animals, determining a more uniform utilization of available forage. By strategically placing water troughs and salt points, grazers are incentivized to graze more homogenously the area at their disposal, reducing the risk of overgrazing in certain areas while mitigating underutilization elsewhere. This approach not only promotes healthier vegetation growth but also supports more sustainable land management practices, ultimately contributing to the long-term productivity and ecological balance of grazing lands.

Necessary equipment and resources

It is essential to adopt an integrated and planned approach that takes into account the specific needs of the production system, the local environment, and sustainability objectives. A combination of machinery (depending on the scale and type of grazing) and means and resources (transport vehicles, fences, water supply points, livestock handling facilities) is required.

Additionally, it is necessary to regularly carry out appropriate management practices of planning and monitoring. This involves assessing stocking rates, pasture rotation, vegetation management, soil quality, and other factors that may affect ecosystem health and livestock productivity.

Finally, trained human resources are needed, with access to information and technical advice on sustainable grazing practices, pasture management, livestock handling, animal health, and other related aspects.

Pros and cons of the strategy

The key to maximizing the benefits of grazing and minimizing its negative impacts lies in careful and sustainable management that considers the environmental, social, and economic aspects of the activity. The benefits of grazing application occur when management is appropriate to the available forage resource. Conversely, disadvantages arise where management does not consider the relationship between stocking rate and forage resource, leading to issues of overgrazing and undergrazing.

PROS (in case of correct management):

- Landscape management: Grazing livestock can help maintain open spaces and prevent the encroachment of forests or dense vegetation. Moreover, grazers promote biodiversity by creating varied vegetation structures and habitats, which support a wide array of wildlife, including birds, insects, and small mammals.
- Soil fertility: Livestock excrete dung, which decomposes and returns nutrients to the soil, improving its fertility and promoting plant growth.
- Forage quality and productivity: The removal of plant biomass and the input of fertility, if managed uniformly in the pasture, allow to maintain both the productivity and the quality of the forage resource high, favoring the palatable species and reducing the abundance of weeds. Economic benefits: Positive socio-economic impact and enhancement of cultural ecosystem services in rural areas where other activities may not be feasible.

CONS (in case of wrong management):

Overgrazing

- Degradation of vegetation and loss of plant biodiversity.
- Soil erosion and loss of topsoil.
- Compaction of soil, reducing water infiltration and root penetration.
- Loss of habitat for wildlife species.
- Excessive nutrient input leading to nitrophilous vegetation with poor or no forage value.

Undergrazing

- Shrub and tree encroachment
- Reduction in the abundance of palatable plant species
- Decline in soil fertility

Additional resources

Allen et al. (2011). An international terminology for grazing lands and grazing animals. Grass and forage science, 66(1), 2.

MITECO (2008). Inventario de tecnologías disponibles en España para la lucha contra la desertificación. https://www.miteco.gob.es/content/dam/miteco/es/biodiversidad/temas/desertificacion-restauracion/0904712280144d9b_tcm30-152587.pdf

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BACK TO SOIL DEGRADATION PROCESS SELECTION

Green manure

Description

Green manuring is a sustainable agricultural practice in which fresh or dried plant material is incorporated directly into the soil to improve its fertility and overall health. This method involves growing special green manure crops such as legumes and other nitrogen-fixing plants that are later plowed back into the soil, enriching it with organic matter and vital nutrients. These plants enter into a symbiotic relationship with soil microorganisms that enable the fixation of atmospheric nitrogen, significantly reducing the need for synthetic fertilizers and mitigating the environmental impact of excessive nitrogen consumption (Rodríguez et al. 2022).

The application of green manure, especially in the form of legumes, has been shown to increase cereal yields. This practice leads to an increase in soil organic carbon and total nitrogen content, which are essential for maintaining and increasing soil productivity (Berry et al. 2002; Guldan et al. 1997). The strategic use of green manure crops, if properly managed, can replace much or all of the nitrogen usually supplied by chemical fertilizers, with significant environmental and economic benefits (Olesen et al. 2007).

The use of green manure methods contributes significantly to sustainable agriculture by improving soil structure, increasing water retention and enhancing microbial diversity. These benefits lead to improved nutrient cycling and a reduction in soil-borne diseases, making green manuring a critical component of sustainable agricultural systems. This practice not only helps to maintain the long-term viability of arable land, but also plays a crucial role in carbon sequestration, which is another environmental benefit as it helps to mitigate climate change (Rodríguez et al. 2022)

Implementation

The plants are usually grown directly in the field (in-situ). After harvesting the main crop, a colourful mixture of green manure plants is sown on the field. Depending on when the next crop is sown in the field, they can grow here until late fall (winter sowing) or until spring (spring sowing, buckwheat, sorghum, vegetables). It is then worked into the soil as green manure. Or, using a special technique, the main crop can be sown directly into the green manure crop that has frozen over the winter or was cut before sowing.

Sometimes the plants are also grown elsewhere (ex situ). They are harvested and incorporated into the soil a few days (15 – 30) before the main crop is sown.

Many crops can be used as green manure. Legumes such as yellow sweet clover and alfalfa are frequently used, but also white clover, red clover, peas and lentils. Non-leguminous crops that fulfil a variety of functions include oats, barley, forage grasses, mustard, rapeseed and buckwheat.

How does the strategy work in relation to the given threat?

Soil erosion

Green manure plays an important role in combating soil erosion by increasing the organic content of the soil, which in turn improves soil cohesion. This increased cohesion helps the soil resist the destructive forces of rainfall and surface runoff, making it less susceptible to erosion. The organic nutrients provided by green manure improve soil structure, making the soil more robust and better able to maintain its integrity against erosive processes.

Fertilizers / nutrient balance

Green manure contributes to the nutrition of the subsequent crop. Although nutrients are extracted from the soil and then incorporated again at the termination of the green manure, N fixed by symbiotic or free N-fixing bacteria during the green manure growth are a net source of N. This reduces the main crop requirements, as part of N is already available in the soil. P and K taken up by the green manure are just a recycle of nutrients that will soon become available again to the main crop through mineralisation. Nevertheless, both P and K soil availabilities will be increased after green manure, and in particular P organic compounds are easily usable by the main crop to a greater extent than mineral-fertiliser-derived P (Battisti et al. 2022).

Green manure might cause a decrease in yield of the main crop only in particular condition, such as severe water shortage.

Biological activity

Green manure increases the spatial and temporal plant diversity resulting in increased diversity of residues and root systems thereby supporting a wider diversity of soil biota. It improves the physical structure of the soil which supports the development of microhabitats for soil biomes. Applying green manure increases the time of vegetation present in the soil which contributes to increased rhizosphere processes providing an increased amount of carbon and nitrogen input that microorganisms can access for nutrients. Stimulating the microbial abundance of the soil by increasing the organic matter and nutrient content and conserve moisture. It is a type of organic fertilize which is an additional direct food source for soil decomposer communities, enhancing their biomass and density. Increases the number of macropores which support the presents of mezzo and macro organisms in the soil.

Soil compaction

The increase of organic matter through incorporation of green manure contributes to the elasticity of the soil and thus contributes to a better resilience against harmful soil compaction. However, the effect of incorporated fresh plant material regarding soil compaction is not as relevant as the impact of living cover crops on soil structure.

Soil structure

Green manure significantly improves soil structure by reducing the bulk density of the soil and improving the soil's ability to retain water. The addition of organic matter from green manure treatments enriches the soil and results in a looser, more friable structure that allows for better root penetration and aeration. This improvement in soil structure not only supports healthier plant growth, but also increases the overall productivity and resilience of the soil (Mosavi et al. 2012).

Soil organic carbon content

The gain in SOC due to green manuring is largely variable with site conditions. Green manure provides easily-degradable organic matter, often with a relatively low C:N ratio, that is rapidly decomposed by soil microorganisms. This not only provides nutrients to the main crop, but also stimulates the growth of soil microorganisms that will end up with an accumulation of stable soil organic matter.

Owing to the use of green manure, an annual change rate of 0.32 tha-1yr-1 of SOC can be expected, based on the meta-analysis of (Poeplau a Don 2015).

Implementation challenges

There are several challenges to overcome when implementing green manure, in particular legal regulations that restrict the use of nitrogen near water protection areas and ecologically sensitive areas. The incorporation of green manure into the soil also releases nitrogen. In addition, when using green manure, good crop rotation is important to maintain the nutrient balance in the soil. For example, after using a legume-based green manure, that enriches the soil with nitrogen, it is advisable to grow cereals or oilseeds instead of another legume to avoid excess nitrogen and reduce the spread of diseases and weeds. This strategic crop rotation and environmental compliance are critical to maximizing the benefits of green manure while ensuring sustainable and compliant farming practices.

Timing is critical to the success of green manure. Green manure crops need to be sown, cultivated and incorporated at specific times to ensure they deliver the maximum benefit in terms of nutrient release and soil improvement. If these steps are timed incorrectly, the effectiveness of the green manure can be compromised, and the intended benefits of soil fertility and soil structure improvement may not be achieved. This need for precise timing can complicate farm management, especially when integrated with the growing cycles of other crops.

Necessary equipment and resources

Cultivating green manure requires specialized equipment and resources, including seed for green manure crops, equipment for seeding, such as seeders or spreaders, and machinery for incorporation, such as plows or rototillers. Initial costs include the purchase of seed and the labor or machinery for seeding and incorporation. However, these investments are often offset by reduced expenditure on mineral nitrogen fertilizers, as many green manure crops can fix nitrogen. Proper management also requires knowledge of optimal planting timing and crop rotation strategies to maximize the benefits of green manure.

Pros and cons of the strategy

PROS

- Green manure (legumes) enables nitrogen fixation in the soil. This reduces the need for mineral fertilizers.
- Green manure interrupts the usual crop rotation, which helps to prevent the development of diseases in agricultural crops.
- Green manure provides soil cover and promotes water retention by improving soil structure. This leads to soil resistance to erosion and other negative influences.
- Green manure helps to “build up” the soil structure over time, which improves aeration, water infiltration and root growth and reduces the risk of soil erosion.
- The use of diverse green manure crops can increase biological diversity in the soil, enhancing ecosystem resilience and function.

CONS

- In special cases, green manure can reduce soil moisture. Green manure crops can utilize moisture that might otherwise be conserved during fallow.
- Initial costs (seeds and labor).
- If not managed properly, some green manure crops can harbor pests and diseases that can be transferred to subsequent crops
- Effective use of green manure requires careful timing and management to ensure that crops are incorporated at the right stage of growth
- Growing green manure crops may mean that land is temporarily not being used for income-generating crops

Additional resources

Microsoft Word - Draft HDC green manure review.doc (organicresearchcentre.com)
icm12.pdf (fao.org)

BACK TO SOIL DEGRADATION PROCESS SELECTION

Agroforestry

Description

Agroforestry is a land-use approach that integrates trees, agricultural crops, and/or livestock in the same area, either simultaneously or sequentially. It is a sustainable practice aimed at improving land productivity, conserving natural resources, and providing economic and social benefits. Agroforestry can take various forms depending on local needs and conditions, such as scattered tree systems in agricultural fields, silvopastoral systems that combine trees and pasture for livestock, or forest-garden systems that integrate fruit trees and vegetables. This approach can contribute to food security, climate change mitigation, biodiversity conservation, and sustainable rural development.

Implementation

The first step is to conduct a thorough site assessment in the areas where agroforestry is planned to be implemented or enhanced. This involves considering factors such as climate, soil, topography, water availability, and human resources. Based on the site assessment, careful selection of tree species, agricultural crops, and/or livestock suitable for the area is essential. It is crucial to choose species that are compatible with each other and with the prevailing site conditions, while also offering a variety of benefits (e.g., food, income, environmental services).

The agroforestry system design should account for the spatial distribution of trees, crops, and/or livestock, taking into consideration factors such as tree spacing, row orientation, crop arrangement, and integration of different components. This process involves land preparation, tree and crop planting, implementation of appropriate management practices, and installation of necessary infrastructure (e.g., irrigation systems, fences).

Figure 25. Agroforestry system combining porcine livestock, traditional olives trees, cork oaks, and oaks in Southern Spain.

How does the strategy work in relation to the given threat?

Soil erosion

Both tree and herbaceous vegetation play a crucial role in protecting the soil from water erosion by mitigating the force and speed of impact on the soil, thereby preventing splash erosion. Furthermore, the deep roots of trees and shallower roots of herbaceous vegetation enhance rainwater infiltration, diminishing runoff and improving soil structure. This is particularly advantageous for soils prone to compaction and erosion.

In instances where vegetative barriers are employed, these serve to capture and retain sediments carried by runoff, thus averting their transport to sensitive areas and adjacent water bodies.

Fertilizers / nutrient balance

Several authors demonstrated that agroforestry systems are characterised by a higher nutrient resource use efficiency. The reason can be different, based on the type of agroforestry association. Different plant nutrient requirements in terms of amount, type and time allow a better utilisation of soil resources. Trees can access nutrients that herbaceous crops cannot acquire, also because they are deeper. Then, the decomposition of their leaves, pruning residues and root turnover provides these nutrients to the other components of the agroforestry system.

In addition, some species can facilitate others, such as the association with legume species provides extra N to the other crops. N fixing ability depend on the plant species and on the soil conditions, and is very difficult to estimate. Some studies have tried to quantify N fixation from trees in tropical trees, but there is a lack of information regarding temperate areas.

Root exudates of some legume species can improve soil phosphorus availability (Ae et al. 1990) or solubilizing soil P (Wezel et al. 2014). All this makes the calculation of crop requirements rather difficult. Nair a Graetz (2004) proposed a Florida P-Index as an indicator that considers mobilisation dynamics and management practices to help planning fertilisation in agroforestry systems. Apart from that, to our knowledge, there is no simple tool to help farmers fertilising agroforestry systems.

In general, agroforestry enhances soil nutrient balance by increasing nutrient availability and diversity, mitigating nutrient leaching, and facilitating natural fertilization via organic matter decomposition. The integration of trees, crops, and/or livestock within the same agroforestry system can broaden the array of nutrient sources accessible to plants.

For instance, trees, which can also mitigate soil nutrient leaching, are capable of extracting nutrients from deeper soil layers and redistributing them through leaf fall and decomposition, thereby benefiting crops unable to access these nutrients independently.

Biological activity

The integration of trees, crops, herbaceous vegetation, and livestock within agroforestry systems creates a more diverse soil environment. This diversity ensures a constant and varied supply of organic substrates for soil microorganisms, thereby fostering greater biological activity.

The improved environmental condition within these systems results in the formation of more favorable microclimates for soil life, such as shaded areas, which offer ideal habitats for microorganisms.

These microhabitats may be supported by the exudation of organic compounds from tree roots and other vegetation.

Increased biological activity and abundance can be recognised around trees. This can be linked to a number of factors. First of all they are perennial plants providing all year around nutrient input through root exudation, and leaf litter. Tree canopy provides shade regulating soil temperature, intercepting rainfall creating micro climat. The leaf litter covers the soil surface decreasing evapotranspiration that supports the survival of soil organisms and their activity.

Soil compaction

Agroforestry naturally prevents any soil compaction on the area cultivated with trees, as these areas are not trafficked, humus gets accumulated, the soils are undisturbed and the permanent deep-rooted vegetation provides nutrition to soil life organisms across the soil profile which provide good soil structure throughout the year. Additionally, agroforestry effectively prevents water and wind erosion processes and thus retain the carbon-rich topsoil on the field, which increases the elasticity of the soil. Thus, agroforestry contributes to resilience against harmful compaction on the entire field.

The presence of trees can alleviate soil compaction by reducing the frequency of tillage and agricultural machinery traffic compared to conventional agricultural systems. This may limit access to certain areas for machinery, which can help to preserve soil structure and prevent excessive compaction.

The deep soil layers can be penetrated by tree roots, breaking up compaction and improving soil structure at depth. Furthermore, the roots from herbaceous vegetation also contribute to soil aggregation and structure improvement.

Soil structure

Agroforestry indirectly contributes to the accumulation of organic matter in the soil. The decomposition of organic matter from tree leaf litter, crop residues, herbaceous vegetation, and livestock manure enhances soil structure by increasing aggregation and porosity formation.

Soil organic carbon content

Agroforestry was recognised by UNFCCC (United Nations Framework Convention on Climate Change) as a practice able to sequester C. Carbon is sequestered both in the soil (as stable SOC, roots, microbial biomass, litter) and in aboveground biomass (wood and leaves). Owing to the great variability of agroforestry systems, their capacity to stock C is largely variable with crops, practices, climate and soil characteristics. The aboveground biomass accumulation is generally higher in humid climate Montagnini a Nair 2004 estimated an average accumulation of 9, 21, 50 and 63 t C ha-1 in semiarid, subhumid, humid and temperate areas, respectively). Conversely, accumulation of C in the soil is more difficult to estimate and is largely variable. According to P. K. R. Nair et al. 2009 C stock accumulated over 10 years is in the range 100-250 kg ha-1 in multi-layer systems in humid tropical areas, but only 5-10 kg ha-1 in extensive arid and semi-arid areas over in 25 years. In temperate areas, some studies conducted in Canada, USA and France reported an accumulation of 13,2 t C ha-1 yr-1 in a barley-poplar system, 2,7 tC ha-1 yr-1 in a forest pasture, 8.4 t ha-1 over 13 years in a poplar system, and 0.1-0.5 t C yr-1 in a nut tree plantation.

The fall of leaves and branches from trees, as well as crop residues and herbaceous vegetation, and the contribution of livestock through manure, provide a continuous source of organic matter to the soil. This organic material undergoes a gradual decomposition process within the soil matrix, fostering enhanced diversity and biological activity, consequently increasing soil organic carbon content.

In contrast to conventional agricultural systems, agroforestry practices typically entail less soil disturbance. This practice serves to preserve the existing organic matter within the soil profile, thereby maintaining higher levels of organic carbon. As a result, agroforestry plays a significant role in climate change mitigation by sequestering carbon within the soil.

Implementation challenges

Designing, planning, and properly managing the agroforestry system is fundamental for ensuring its long-term viability. This encompasses various practices such as irrigation management, tree pruning techniques, weed and pest control strategies, fertilization practices, and the implementation of controlled grazing practices in silvopastoral systems.

Moreover, regular monitoring of the agroforestry system is necessary to assess its performance and make necessary adjustments. This involves monitoring different parameters such as tree growth, crop productivity, soil health indicators, livestock condition, and other relevant indicators depending on the socio-economic activity within the system. In this regard, identifying viable markets for agroforestry products and establishing strong value chains pose a significant challenge. Lack of access to markets or subdued demand for agroforestry products may deter farmers from embracing these practices.

Lastly, discordance between prevailing agricultural and environmental policies and the objectives of agroforestry pose a significant impediment to its widespread adoption.

Necessary equipment and resources

The required equipment and resources for implementing an agroforestry system vary significantly depending on the specific site conditions and the objectives of the proposed system. Additionally, active engagement and collaboration with local farmers and other stakeholders play a pivotal role in ensuring the success of the project.

The scale and type of agricultural crops integrated within the agroforestry system dictate the types of machinery required (e.g., tractors, plows, seeders, etc.). Additionally, the installation of irrigation systems and water supply infrastructure may be necessary to ensure adequate water supply for both crops and livestock.

Regarding seeds and seedlings, resilient and locally adapted varieties is essential for sustainable agroforestry practices. Furthermore, the installation of protective structures to shield crops and trees such as fences or windbreaks may be warranted in areas prone to potential damage from animals, strong winds, or other environmental factors.

The use of storage facilities and other infrastructure for the management and care of livestock becomes necessary when considering the harvested products and the potential livestock integration within the system. These facilities play a crucial role in ensuring the efficient handling and preservation of agricultural produce and livestock.

Pros and cons of the strategy

In general, the benefits of agroforestry typically outweigh the disadvantages, especially in terms of long-term sustainability and resilience to environmental and economic changes. However, it is imperative to consider the challenges and carefully assess the local context when implementing agroforestry systems.

PROS:

- Helps prevent soil erosion, improve water retention, and protect water resources by reducing runoff and nutrient leaching.
- Contributes to climate change mitigation by capturing and storing carbon in plant biomass and soil, helping to reduce greenhouse gas emissions.
- Provides habitats for a variety of plant and animal species, fostering biodiversity and promoting wildlife conservation.
- Offers diverse sources of income to farmers by integrating trees, crops, and/or livestock in the same area, thereby enhancing economic resilience, particularly in areas where other types of activities may not be viable.

CONS:

- Requires careful and continuous management to maintain the balance between different components and maximize benefits. Lack of proper management can lead to issues such as competition between crops and trees, proliferation of pests and diseases, and soil degradation.
- Successful implementation requires significant time, effort, and technical knowledge to effectively plan, establish, and manage agroforestry systems.
- Potentially requires higher initial investments compared to conventional agricultural systems due to the necessity of integrating different subsystems and activities, each with their respective characteristics, into the agroforestry system.

Additional resources

Agroforestry in the European Union (2020). Briefing EPRS. https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/651982/EPRS_BRI(2020)651982_EN.pdf

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BACK TO SOIL DEGRADATION PROCESS SELECTION

Nutrient management plan

Description

The calculation of crop requirements ensures that the crop needs are respected to maximise yield and reduce plant stress (that can severely affect yield sanitary traits, (Blandino et al. 2022), but in a context of soil health maintenance, it also ensures that no excessive or insufficient amounts of fertilisers are used. Not only the absolute amount of single nutrients should be supplied to the soil, but also the ratio between them should be taken into account, as a soil correct functioning requires that all nutrients are available at a correct rate, or one might limit soil life, or deplete soil reserves in a way that menace its future (Lal 2015). The basic approach to the nutrient management plan is generally the mass balance of imports and exports from a field.

In this context, a provisional nutrient management plan is a fundamental tool to maintain soil functioning and quality. A basic version of this tool is the provisional seasonal balance, and the main information that it requires are: crop type, expected yield, soil organic matter content (and factors that may affect its yearly mineralisation, such as soil pH, clay content, temperature and humidity), soil available P and K (sometimes also mineral N), crop N-fixation capacity, previous crop residues type and management, previous distributions of organic amendments, and factors that influence losses of distributed fertilisers, in particular those of organic fertilisers (such as frequency, timing and soil conditions at spreading).

The mass-balance approach has several advantages, such as the fact that is easy to explain to farmers, relatively easy to apply and integrate into tools, and allows tracing of fertilisation operations. Nevertheless, it is a rather rough approach that does not take into consideration all processes, year-to-year variability and site variability (when adopting standard coefficients such as concentrations or efficiencies).

Implementation

A nutrient management plan in its simplest form is a spreadsheet that allows to calculate nutrient requirements, based on provisional crop production and standard NKP requirements. More complex forms include the soil supply (of mineral N, and/or of available P and K) measured before planting., and the calculation of some losses based on the soil and climate characteristics, and management techniques used to distribute fertilisers. In this case, software and App tools support farmers with standard calculation methods. Some tools are free and provided by the public authorities, while some others are commercial.

The existence of several algorithms, commercial or public, that provide a different outcome in terms of fertiliser requirements, may confound the farmer and prevent its adoption. More complex versions of the nutrient management plan can be regarded as Precision fertilisation

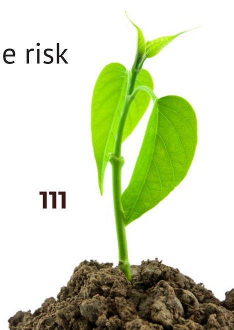
How does the strategy work in relation to the given threat?

Soil erosion

No direct significant effect.

Fertilizers / nutrient balance

A nutrient management plan is the best way to plan fertilisation of a cropping system and reduce the risk of menacing the equilibrium of soil nutrients.



Biological activity

Controlling the input of excess nutrient can support the growth of microbial communities that specializes in decomposing recalcitrant litter. Reducing excess nitrogen and phosphorus would aid stabilizing the mycorrhizal fungi and cyanobacteria communities. Nutrient overloading should be prevented as it reduces the number of nitrogen fixing bacteria and promotes the abundance of taxa involving in denitrification and nitrification. With excess nutrient both the soil microbial composition and plant composition changes. Due to an increased amount of nutrients both plant and soil microbial community composition changes and have a strong input on the carbon cycle resulting in the reduction of the microbial biomass pool.

Soil compaction

There is no direct link between a nutrient management plan and the soil compaction status. However, proper nutrient management protects against nutrient deficiency and a calcium budget imbalance, which improves a stable soil life activity and formation of a good soil structure. It also fosters good plant and root development. Thus, a nutrient management plan as part of good soil management contributes to the prevention of degradation processes, including harmful soil compaction.

Soil structure

No significant positive impact.

Soil organic carbon content

The adoption of a nutrient management plan affects the carbon balance through influencing the production of residues and the amount of organic fertilisers supplied. A balanced system, where all nutrients are supplied in an amount that is not in excess or depletion of the crop requirements, ensures a good environment for soil life also, thus promoting the stabilisation of SOM.

Implementation challenges

The adoption of a Nutrient management plan requires the calculation of crop requirements and soil provisions. Therefore, some data regarding the crop type and expected yield, previous crop residue amount and management, soil status and climate data are needed for each field. A digital farm operation register can help the farmer reduce the manual input of data and the time required to fill the form.

An agronomist is often needed to help farmers understand and translate into practice the suggestions that a software provides as a simple indication of the annual fertilisation amount that should be supplied to crops. In addition, the agronomist can help the farmer identifying the best timing for nutrient fractionation, based on the characteristics and constraints of each farm.

Necessary equipment and resources

Theoretically, a soil analysis should be available for each field, or at least for each soil type X cropping system combination. The analysis should be updated every 4-5 years to monitor the SOM, P and K concentrations, and include a soil texture analysis. If a soil test is missing, the nutrient management plan will be incomplete.

Some nutrient management plans are in the form of a software or App, therefore a computer and a smartphone are necessary to input data. Most of apps require an internet connection and store data in the cloud. Depending on the coverage of internet access in rural areas, the farmer could also access the input and output forms when in the field.

A provisional nutrient management plan is also the basis for the implementation of precision fertilisation tools.

Pros and cons of the strategy

PROS:

- Maximisation of crop yield and quality
- Improved soil health du to more balanced nutritional status
- Reduction of costs due to excessive fertiliser distributions
- Reduction of losses to the environment, with beneficial effects on water and air quality

CONS:

- A fee can be asked to use commercial apps
- Some data will require a manual input by the farmer
- A privacy policy on data should be carefully read and uneerstood by the farmer

Additional resources

https://www.farmers.gov/conservation/nutrient-management
https://www.fao.org/agriculture/crops/thematic-sitemap/theme/compendium/scpi-practices/integrated-nutrient-management/en/

BACK TO SOIL DEGRADATION PROCESS SELECTION

Precision fertilisation

Description

Precision fertilization aims on an efficient use of resources and the prevention of environmental pollution. The practice is fundamentally supported by information technology and comprehensively integrates information technology and agricultural production by positioning, timing, and quantitative implementation of a set of modern agricultural operation and management systems in accordance with spatial variation. It is based on the three pillars 1) field information collection, 2) information management and decision-making, 3) and execution systems (Y. Lu et al. 2022).

Implementation

Precision fertilization is part of precision farming. Thus, precision fertilisation may be accompanied with precision drilling, plant protection and tillage, which can all be performed on a site-specific basis with the help of application maps.

How does the strategy work in relation to the given threat?

Soil erosion

No significant direct effect.

Fertilizers / nutrient balance

Precision fertilisation tools are the advanced level of a basic nutrient management plan, to decide about the correct fertilisation of a crop. Therefore, a precision fertilisation approach, both in time and in space, is the best approach to ensure that the crop and the soil receive the right amount of nutrients to ensure profitable yield with a good quality, and protects the environment from excessive nutrient load.

Biological activity

Precision fertilization enhances the growth of microbial communities. Regulating the nitrogen and phosphorus input would aid stabilizing the presents of mycorrhizal fungi and cyanobacteria communities and promoting the growth of bacteria taxa responsible for nitrogen fixation. Precision fertilization facilitates keeping the balance between the different soil microbial and plant communities. It increases the organic matter and nutrient content as well as conserving soil moisture which stimulate the abundance of a diverse microbial community enhancing the microbial biomass pool. It improves the physical structure of the soil which supports the development of microhabitats for soil biomes and contributes to increased rhizosphere processes providing an increased amount of carbon and nitrogen input that microorganisms can access for nutrients.

Soil compaction

There is no direct link between precision fertilization and the soil compaction status. However, proper and spatially optimized nutrient management protects against nutrient deficiency or surplus and a calcium budget imbalance, which improves a stable soil life activity and formation of a good soil structure. Thus, precision fertilization may contribute to the resilience against harmful soil compaction.

Soil structure

No significant positive impact.

Soil organic carbon content

No significant positive impact.

Implementation challenges

The main implementation challenge is the economic viability of precision fertilisation. The expenses include the cost of site-specific spreading equipment and software and the cost of acquiring information and training. Additionally, the local conditions and key metrics such as the farm size, area under cultivation, crop proportion and variability of the fields are also important when making any economic assessment (Y. Lu et al. 2022). At fields with minimal variation of soil quality, the effect of site-specific fertilisation will be minimal and the technique will probably not be cost-efficient.

Necessary equipment and resources

Precision fertilization support services are supported by several companies, which provide various combinations of hard- and software. The minimum requirement are specific fertilizer spreading/distribution tools and software and the spatial information on soil quality.

A compilation of various systems for 1) field Information collection, 2) information management and Decision-Making Systems, and 3) execution system of variable rate fertilization technologies are provided by Y. Lu et al. (2022), including examples for each system.

Pros and cons of the strategy

Precision fertilization may reduce up to 50 percent of the regular application rate without any reduction of yield. Consequently, precision fertilization has positive effects on almost all plant production and environmental protection aspects, including nutrient balance, soil life, water body protection, and cost efficiency of fertilizer application.

However, all positive aspects regarding soil physical, chemical and biological aspects must be related to economic feasibility. The economic viability of precision fertilisation depends on various factors. This includes the cost of site-specific spreading equipment and software and the cost of acquiring information and training. Additionally, the local conditions and key metrics such as the farm size, area under cultivation, crop proportion and variability of the fields are also important when making any economic assessment (Lu et al., 2022). At fields with minimal variation of soil quality, the effect of site-specific fertilisation will be minimal and the technique will probably not be cost-efficient.

Additional resources

STERF-Precision-fertilisation-from-theory-to-practice.pdf (ngagolf.nl)
IO1_PreAgri_handbook-EN.pdf (europa.eu)

BACK TO SOIL DEGRADATION PROCESS SELECTION

Regenerative agriculture

Description

Regenerative agriculture is a combination of agricultural practices that are aimed at improving soil health status. Rather than a list of operations, it is a system of farming principles and practices based on the whole ecosystem approach. Some of the key techniques used in regenerative agriculture are no tillage, cover crops, increasing biodiversity, rotation cropping, attracting natural predators of pests and integrating livestock.

The term appeared for the first time in the early 1980s, but only in the last 15 years researchers have dedicated to it with a scientific approach and tried to shape what regenerative agriculture meant. More recently, several organizations and industries in the agri-food chain have started to promote regenerative agriculture principles.

Implementation

The implementation of regenerative agriculture objectives is site-specific and requires preliminary studies. The groups of practices include the following:

- Minimise soil disturbance: adoption of no-till ore reduced-till practices.
- Extend the time soil is covered: using cover crops or permanent crops.
- Diversify crops in time and space: through rotations and intercropping practices.
- Precision application of biological and chemical inputs: as precision placement techniques applied to seeds, crop protection and fertilisation.
- Integrate livestock when possible: as the best way to close cycles at the farm, through grazing cover crops and residues, using manure and compost as fertilisers.

A first step is in fact the soil status mapping and the development of a specific action plan. Farmers might need specific training on some practices. Then, a continuous monitoring of the actions is needed to refine the implementation at each site.

How does the strategy work in relation to the given threat?

Soil erosion

Regenerative agriculture generally improves soil condition and quality. The soil is more resistant to the effect of precipitation and surface runoff. Consequently, the soil is more resistant to erosion.

Fertilizers / nutrient balance

If correctly applied, regenerative agriculture offers a prefect framework to apply the correct amount of nutrients, even using precision application techniques. Nevertheless, the calculation of crop requirements are more challenging in environments where N fixation, intercropping, agroforestry practices are adopted.

Biological activity

No-till or reduced tillage promote the biological activity of the soil by retaining organic residues on the surface, creating a favorable environment for soil microorganisms. The absence or reduction of tillage helps to maintain a diverse microbial community and improve soil health. The remaining crop residues serve as a source of nutrients and promotes the growth of beneficial bacteria and fungi. This increased microbial activity helps improve nutrient cycling, soil structure and overall ecosystem resilience. No-till creates conditions favourable for fungi over bacteria as primary decomposers. The arbuscular mycorrhizal fungi (AMF) density and species richness also increases by no-till. Soil ecosystem engineers like earthworms and termites are also benefit from no-till by preventing the bodies, burrows and nests to be destroyed.

Cover cropping increases the spatial and temporal plant diversity resulting in increased diversity of residues and root systems thereby supporting a wider diversity of soil biota. Cover crops improve the physical structure of the soil which supports the development of microhabitats for soil biomes. The use of cover crops increase the time of vegetation present in the soil which contributes to increased rhizosphere processes providing an increased amount of carbon and nitrogen input that microorganisms can access for nutrients. Cover crops stimulating the microbial abundance of the soil by increasing the organic matter and nutrient content and conserve moisture.

Increased plant diversity resulting in increased diversity of residues and root systems thereby supporting a wider diversity of soil biota. It improves the physical structure of the soil which supports the development of microhabitats for soil biomes. It contributes to pest and disease control and retrieve available nutrients that provides favourable conditions for soil biota.

Grazing on soil organisms can have both positive and negative effects. Over grazing has the most negative impact on soil organisms. Trampling, soil compaction, denudation, resource competition and anthelminthic residues in faces are the most damaging factors. Soil pores would collapse starting with the largest where larger size soil animals live and ending with the micro pores which are inhabited by bacteria. Soil compaction also restricts the transport of water through the soil. This under dry soils conditions would cause water deficit and soil erosion, limiting plant growth and soil biodiversity. Under wet soils oxygen would become a limiting factor for many soil fauna particularly for invertebrates. Anthelminthic residues have a negative effect on the number and development of beetle larvae. Defoliation stimulate plant regrowth as well as the increase in root exudation which increases the growth of microorganizms and the abundance of soil biota.

Soil compaction

Regenerative agriculture is a collective term for measures that all have a positive impact on the soil structure and thus on the compaction status and resilience of the soil. A reduction of tillage and mechanical loosening may initially lead to increased compaction. However, after several years of regenerative management, a stable soil structure with a well-connected micro- and macro-pore system develops. In combination with cover crop management harmful soil compaction may be prevented. The above ground biomass and roots provide nutrition to soil life organisms which contribute to a good soil structure. Roots also loosen the soil during growth. Furthermore, even dead cover material protects the soil from erosion and serves as food for soil life organisms.

Soil structure

No significant positive impact.

Soil organic carbon content

The application of manures, or composts, the use of cover crops and promotion of soil life are all good practices that even when applied separately can improve the soil carbon content. However, at the moment there is a lack of scientific data on the ability of regenerative agriculture to increase SOC content, also because of the nature of its approach, that should be adapted to a variety of agricultural situations.

Implementation challenges

The adoption of regenerative agricultural approaches requires knowledge of new practices that could require specific training by farmers. Moreover, a monitoring of the achieved results can help the farmer fine-tune the application practice to maximise the good results. All practices will need some years before results can be visible. The set of indicators that should be monitored along the application of regeneration practices span from erosion, compaction, soil structure degradation, soil life status, soil C content, soil nutrient status and field nutrient balance.

Necessary equipment and resources

A series of specific machinery is needed for the farm implementation of regenerative agricultural practices. For details, please refer to single practices described in this document.

Pros and cons of the strategy

PROS:

- Better soil health and resilience
- Improvement of environmental quality

CONS:

- New knowledge is required
- Production will not necessarily increase in the short term
- New machinery might be needed in the farm

Additional resources

https://www.syngentagroup.com/regenerative-agriculture
https://regenerationinternational.org/why-regenerative-agriculture/

BACK TO SOIL DEGRADATION PROCESS SELECTION

Economic assessment and costs

Gross Margin calculation

The gross margin of a farm enterprise is the difference between its gross income and its variable costs. Variable costs are those costs that vary in proportion to the size of the enterprise, such as fertilizers, fuel, and cartage. GM can be calculated based on a hectare or on a currency unit (EUR for example). The GM table (Table 3) have to be prepared for every crop type in the pilot farm. Table 3 presents the information needed for GM calculation. The parameters in Table 3 are estimated with the assumption that no soil restoration strategy is applied.

Table 3. Gross margin calculation.

Crop type:				
Income	Measure (kg, l, ...) per ha	Yield	Price	Total
			EUR	EUR
Main product				
Side product 1	kg			
Side product 2	kg			
Subsidy	EUR			
Total income				
Vatable Costs		**Quantity**	**Price**	**Value**
			EUR	**EUR**
Ceeds	kg			
	kg			
Fertilzers	kg			
	kg			
	kg			
Plant protection	**l**			
	l			
	l			
Labor				
Manual labor	Person days			
Harvesting	Person days			
Marketing	EUR			
Packing	EUR			
Contracts				
Plowing	EUR			
Disking	EUR			
Harvest	EUR			
Swoing	EUR			
Fertilizing and spraying	EUR			
Equipment Rental				
Irrigation	M^3			
Other costs				
Fuel	l			
Total Variable Costs				

Soil restoring strategies/alternatives that can be applied in the pilot farm

It is possible to implement several different soil restoration strategies separately in the pilot farm. Alternatively, two or more soil restoration strategies can be implemented simultaneously in a single scenario.

Soil restoring scenarios

Implementing soil restoration strategies can change both costs and income on the farm. For this reason, it is necessary to fill in the GM calculation table for each crop and applied soil restoration strategy.

Investment costs

Implementing a soil restoration strategy sometimes requires making upfront investments. For each soil restoration strategy in the pilot farm, it is necessary to estimate the amount of initial investment.

Fixed costs

It is also necessary to estimate the fixed costs. Fixed costs apply to the farm as a whole and remain steady as production changes. Fixed Costs are those costs which either cannot readily be allocated to a specific enterprise or do not vary with small changes in the scale of the individual enterprise. Examples of Fixed Costs are labour (including payments in kind), machinery repairs and depreciation, rent and rates, general expenses, interest.

Financial support

Austria

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Non inversion tillage	ÖPUL	applies only regionally - 110 €/ha	only valid when conditionality rules are followed
No-till	ÖPUL	80 €/ha combines with cover crops 80-220 €/ha	only valid when conditionality rules are followed
Strip-till	ÖPUL	80 €/ha combines with cover crops 80-220 €/ha	only valid when conditionality rules are followed
Cover crops	ÖPUL	various option ranging from 80-220 €/ha	only valid when conditionality rules are followed
Crop residue incorporation	N/A	N/A	N/A
Mulching	ÖPUL	50 €/ha combines with cover crops 80-220 €/ha	only valid when conditionality rules are followed
Grassing		part of conditionality regulation - good ecological and agrciultural condition (GLÖZ 1)	no conversion from grassland into arable allowed
Strip cropping	N/A	N/A	N/A
Contour farming	N/A	N/A	N/A
Sustainable crop rotation	ÖPUL		part of conditionality rules - not more than 75% of same crop in 3 years
Vegetated buffer strips	ÖPUL	550 €/ha, also as part of GLÖZ 4 buffer strips along waterways are obligatory	only valid when conditionality rules are followed
Hedgerows	regional government	variable	
Reservoir tillage	N/A	N/A	N/A
Retention ditches	N/A	N/A	N/A
Drainage ditches	N/A	N/A	N/A
Fish scale pits	N/A	N/A	N/A
Terracing	N/A	N/A	N/A
Sustainable irrigation	N/A	N/A	N/A
Organic fertilization	N/A	N/A	N/A
Planning traffic frequency	N/A	N/A	N/A
Heavy traffic control	N/A	N/A	N/A
Reduction of grazing intensity	N/A	N/A	N/A
Grazing management	N/A	N/A	N/A
Green manure	N/A	N/A	N/A
Agroforestry	N/A	N/A	N/A
Nutrient management plan	N/A	N/A	N/A
Precision fertilisation	N/A	N/A	N/A
Regenerative agriculture	N/A	N/A	N/A

Bulgaria

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Non inversion tillage	N/A	N/A	N/A
No-till	N/A	N/A	N/A
Strip-till	N/A	N/A	N/A
Cover crops	1. CAP, Eco scheme for preservation and restoration of soil potential	66 euro/ha	Farmers who meet the requirements for active farmers.Areas where the total amount of N (nitrogen) per hectare exceeds 150 kg are not supported.
Crop residue incorporation	N/A	N/A	N/A
Mulching	N/A	N/A	N/A
Grassing	N/A	N/A	N/A
Strip cropping	N/A	N/A	N/A
Contour farming	1. CAP, Eco scheme for crop rotation	Farms up to 10 ha with two crops - 48 euros/ha; Farms of 10-30 ha with three crops - 37 euros/ha; Farms over 30 ha with four crops – 20 euros/ha.	The intervention is applicable to arable land and/or the areas occupied by medicinal and aromatic crops.
Vegetated buffer strips	1. CAP, Eco scheme for ecological infrastructure	696.86 euros/ha for arable land for areas and activities above DZES 8; 286.33 euros/ha for arable land for activities above DZES 8; 901.17 euros/ha for permanent plantations; 290.00/ha for permanently grassed areas;	The intervention is applicable to arable land, permanent crops and permanently grassed areas;
Hedgerows	1. CAP, Eco scheme for ecological infrastructure	696.86 euros/ha for arable land for areas and activities above DZES 8; 286.33 euros/ha for arable land for activities above DZES 8; 901.17 euros/ha for permanent plantations; 290.00/ha for permanently grassed areas;	The intervention is applicable to arable land, permanent crops and permanently grassed areas;
Reservoir tillage	N/A	N/A	N/A
Retention ditches	N/A	N/A	N/A
Drainage ditches	N/A	N/A	N/A
Fish scale pits	N/A	N/A	N/A
Terracing	1. CAP, Eco scheme for ecological infrastructure	901.17 euros/ha for permanent plantations;	The intervention is applicable to arable land, permanent crops and permanently grassed areas;
Sustainable irrigation	N/A	N/A	N/A

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Organic fertilization	1. CAP, Eco scheme for preservation and restoration of soil potential - promotion of green fertilization and organic fertilization	66 euro/ha	The intervention is applicable to arable land, permanent crops and permanently grassed areas. Use of external organic soil improvers: from aerobic, anaerobic, through worms and after thermal treatment plus injection of liquid manure within 4 hours of application - at least 10% of the crop's nitrogen needs is through organic fertilization and the maximum amount of nitrogen up to 150 kg/ha.
Planning traffic frequency	N/A	N/A	N/A
Heavy traffic control	N/A	N/A	N/A
Reduction of grazing intensity	1. CAP, Eco scheme for extensive maintenance of permanently grassed areas	80 euro/ha	• The intervention is applicable to permanently grassed areas Eligible beneficiaries: only animal breeders who have both animals and permanently grassed areas for grazing; Permissible practices: extensive grazing with grazing animals, with grazing ranging from 0.3 to 1 RU/ha for a minimum of 60 days during the year; • Requirements: ban on plowing pastures; mandatory Grazing Plan (grazing types, period), prepared by competent persons, which is checked by the DFZ.
Grazing management	1. CAP, Eco scheme for extensive maintenance of permanently grassed areas	80 euro/ha	• The intervention is applicable to permanently grassed areas Eligible beneficiaries: only animal breeders who have both animals and permanently grassed areas for grazing; Permissible practices: extensive grazing with grazing animals, with grazing ranging from 0.3 to 1 RU/ha for a minimum of 60 days during the year; • Requirements: ban on plowing pastures; mandatory Grazing Plan (grazing types, period), prepared by competent persons, which is checked by the DFZ.

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Green manure	1. CAP, Eco scheme for preservation and restoration of soil potential - promotion of green fertilization and organic fertilization	66 euro/ha	The intervention is applicable to arable land, permanent crops and permanently grassed areas. Use of external organic soil improvers: from aerobic, anaerobic, through worms and after thermal treatment plus injection of liquid manure within 4 hours of application - at least 10% of the crop's nitrogen needs is through organic fertilization and the maximum amount of nitrogen up to 150 kg/ha.
Agroforestry	1. CAP, Eco scheme for ecological infrastructure	696.86 euros/ha for arable land for areas and activities above DZES 8; 286.33 euros/ha for arable land for activities above DZES 8; 901.17 euros/ha for permanent plantations; 290.00/ha for permanently grassed areas;	The intervention is applicable to arable land, permanent crops and permanently grassed areas;
Nutrient management plan	N/A	N/A	N/A
Precision fertilisation	N/A	N/A	N/A
Regenerative agriculture	1. CAP, Eco scheme for preservation and restoration of soil potential	66 euro/ha	Farmers who meet the requirements for active farmers.Areas where the total amount of N (nitrogen) per hectare exceeds 150 kg are not supported.

Czech Republic

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Non inversion tillage	only as cover crops support - bellow	1250 €/ha first 4 ha (farms < 10 ha), for farms respecting GAEC	First 150 ha higher subsidy, smallest farms - firs 4 ha special subsidy; with an area of more than 150 ha – min. 4 different crops. winter crops and spring crops = 1 crop; Soil organic matter: on an area equivalent to at least 35% of arable land
No-till	only as cover crops support - bellow		First 150 ha higher subsidy, smallest farms - firs 4 ha special subsidy; with an area of more than 150 ha – min. 4 different crops. winter crops and spring crops = 1 crop; Soil organic matter: on an area equivalent to at least 35% of arable land

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Strip-till	only as cover crops support - bellow		First 150 ha higher subsidy, smallest farms - firs 4 ha special subsidy; with an area of more than 150 ha – min. 4 different crops. winter crops and spring crops = 1 crop; Soil organic matter: on an area equivalent to at least 35% of arable land
Cover crops	CAP - ecoscheme cover crops	154 €/ha	Inter/cover crops to improve soil structure
	CAP - ecoscheme cover crops	152 €/ha	Inter/cover crops against soil compaction
	CAP - INTEGRATED GRAPEVINE PRODUCTION	334 - 672 €/ha (higher for green fertilizing and zero herbicides)	min. 0.5 ha of vineyard; from the second year of the commitment to remove and dispose of dead grapevine bushes or parts thereof no later than 15 May of the following calendar year, • not to apply herbicides in the inter-row and handling area of the vineyard • establish a stand with a specified seed mixture at least in the second year of the commitment no later than in the second year of the commitment with a specified seed mixture at least in the minimum seeding rate of 20 kg/ha of the vineyard
Crop residue incorporation	N/A	N/A	N/A
Mulching	N/A	N/A	N/A
Grassing	CAP - ecoscheme GRASSING arable land	312 €/ha (common grass), 348 €/ha (rich species grass), 1114 €/ha (regional grass, first year)	min. 0.5 ha of standard arable land, permanent grassland must not be registered on parcel from 1 January 2015.
		337 - 390 €/ha (infiltration regions 312 €/ha)	grassing along water body or in infiltration regions
Strip cropping	N/A	N/A	N/A
Contour farming	N/A	N/A	N/A
Sustainable crop rotation	N/A	N/A	N/A
Vegetated buffer strips	CAP - FARM-WIDE ECO-PAYMENT	600 €/ha	protective strip along the water, 12 meters wide, fields to 10m from stream. Buffer strips along waters can be used to meet the proportion of non-productive areas.
	CAP grassing runoff concentration pathways	482 €/ha	grassing waterways

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Hedgerows	Feed biobelt	676 €/ha	min. 2 ha of standard arable land in total; max. 50% of the applicant's standard arable land in the LPIS, with a width of at least 6 m and a maximum of 24 m, with a continuous length of at least 50 meters, to be left in the same area for 2-3 consecutive calendar years, then to incorporate the biobelt into the soil, to establish a subsequent nectar-producing biobelt, not to use the area of the biobelt for the movement of agricultural or other machinery, or as a headland
	Nectar biobelt	597 €/ha	the same as above
Reservoir tillage	N/A	N/A	N/A
Retention ditches	N/A	N/A	N/A
Drainage ditches	N/A	N/A	N/A
Fish scale pits	N/A	N/A	N/A
Terracing	N/A	N/A	N/A
Sustainable irrigation	SZIF, Ministry of Agriculture	3720 €/ha of newely built drip irrigation, up to the CZ budget limit	drip irrigation in tree crops (hay, wine, orchard, tree plantations), except Prague
Organic fertilization	N/A	N/A	N/A
Planning traffic frequency	N/A	N/A	N/A
Heavy traffic control	N/A	N/A	N/A
Reduction of grazing intensity	N/A	N/A	N/A
Grazing management	CAP - ecoscheme TREATMENT OF EXTENSIVE GRASSLAND	91 - 352 €/ha depending on location and management scheme, including controlled grazing and listed bird species protection	min. 2 hectares of permanent grassland, in the fifth year of the commitment when increasing the included area and concluding a new five-year commitment
Green manure			
Agroforestry	CAP - agroenvi agroforestry	3700 - 9000 €/ha depending on the fruit type and No. of trees per ha, up to the CZ budget limit; 754 €/ha/year for following 5 years	Restructuring of fruit orchards, i.e. the necessary improvement of the health of fruit trees and improvement of the quality of produced fruit. Preffered for bio-production but conventional can apply
	CAP - conversion arable to forest	2923-3879 €/ha for planting; 643 €/ha for protection, 190-459 €/ha for lost of production of arable	On demarcated agricultural land suitable for afforestation (layer in LPIS) - steep slopes, min 0.5 ha, converting parcel type to forest permanently
Nutrient management plan	N/A	N/A	N/A
Precision fertilisation	CAP - ECOPAYMENT – PRECISION FARMING	15 €/ha	application of N fertilizers on the basis of a corrective satellite signal or a crop condition sensor

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Regenerative agriculture	SZIF, Ministry of Agriculture	- cucumbers: € 28/ ha - tomatoes: € 31/ ha - peppers: € 20/ ha, Sunflower: 16 €/ha - oilseed rape: 47 €/ha - Maize: 60 €/ha - cereals: 50 €/ha - legumes: 25 €/ ha; up to the CZ budget limit	Costs of acquisition and use of biological plant protection as a substitute for the application of chemical plant protection.
	SZIF, Ministry of Agriculture	in closed growing areas (listed by law), 300 €/ha for potatoes, 2€ per kg of seed for others	Increasing the quality of crop production by substituting chemical treatment and preventing the spread of economically serious viral and bacterial diseases; Purchase/ purchase of recognised seed potatoes to prevent the spread of quarantine potato bacteriosis. similar is for other seeds (sugar beet, maize for food, beans, peas, flax, hemp)
	CAP - limited pesticides use in selected watersheds	151 €/ha	min. 1 ha of standard arable land with the delimitation of the crop cultivation layer with the restriction of the use of pesticides (in the LPIS) - for drinking water reservoirs' watersheds
	CAP - Ecologic farming	100 €/ha (grassland), 760-800 €/ha (strawberries, fruits), 130 €/ha (perennial forage), 246 €/ha (arable), 510 - 850 €/ha (orchards, vineyards, hop)	FARMING respecting the law for ecologic farming, It can be applied to crops of permanent grassland, standard arable land, grassland, orchard, vineyards or hop fields.

China

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Non inversion tillage	N/A	N/A	N/A
No-till	1. Heilongjiang Provincial Department of Agriculture and Rural Affairs, Heilongjiang Provincial Department of Finance, "Implementation Plan for Conservation Farming of Black Soil in Heilongjiang Province in 2023"	The first stage is to cover a small amount of straw and return it to the field. Before sowing on the surface, the straw coverage rate should be within 30%. In spring, there will be no (less) tillage and sowing, and a subsidy of 20 yuan/mu will be given for the operation. The second stage is to partially cover the straw and return it to the field. The straw coverage rate before surface sowing is between 30% -60%. In spring, no (less) tillage and sowing will be allowed, and a subsidy of 35 yuan/mu will be given for the operation. The third stage is to cover a large amount of straw and return it to the field, with a straw coverage rate of 60% or above before surface sowing. In spring, no (less) tillage and sowing will be allowed, and a subsidy of 60 yuan/mu will be given for the operation. During sowing, soybean straw can be detected on the surface, and a subsidy of 30 yuan/mu will be given to qualified plots for operation.	In 2023, the province (excluding agricultural reclamation) will provide policy subsidies for straw covering, returning to the field, and free (less) tillage and seeding operations for previous crops of corn, sorghum, millet, wheat, and soybeans (including miscellaneous beans)
Strip-till	1. Agriculture and Rural Bureau of Beihu District, Chenzhou City, Hunan Province, "Announcement of 2023 Soybean and Corn Striped Compound Planting Subsidy"	Farmers: 168 yuan/mu; Core demonstration area for soybean and corn strip compound planting: 50000 yuan for areas over 200 acres, 40000 yuan for areas over 100 acres	Farmers and core demonstration areas of soybean and corn strip compound planting
	2.Agriculture and Rural Bureau of Zecheng County, Shangqiu, Henan Province," Notice of Zecheng County on the Cashing of subsidy funds for soybean and corn belt composite planting in 2023"	199.99 yuan/mu	Implementation entity of soybean and corn strip compound planting task
Cover crops	1. Agriculture and Rural Affairs Bureau, Gaoping District, Nanchong City, Sichuan Province, "Rural Revitalization" 633 Action Agricultural Industry Development Support Measures (draft for comment)"	200 yuan/mu	Planters who apply green manure such as clover, vetch, and purple sweet potato to perennial crops such as citrus and Sichuan pepper, and achieve good coverage and grass control effects

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Cover crops	2.The Ministry of Finance and the Office of the People's Government of Meixian County," Implementation Plan for the Pilot Work of Replacing Chemical Fertilizer with Organic Fertilizer for Fruit, Vegetable and Tea in Meixian County in 2018"	100 yuan/mu	Business entities implementing the "natural grass+green manure" model
Crop residue incorporation	1.Heilongjiang Provincial Department of Agriculture and Rural Affairs,"Notice on Further Clarifying the Subsidy Policy for Comprehensive Utilization of Straw in Heilongjiang Province in 2023 (Province)"	10 yuan/mu	Operators or growers in Heilongjiang Province who return straw residues and roots to the field.
	2.Hainan Provincial Department of Finance," Notice on Issuing the Second Batch of Agricultural Resources and Ecological Protection Subsidy Funds in 2023 in Advance"	According to different standards for mechanized return of rice straw to the field, classified subsidies will be implemented. Among them, ① the subsidy standard for "single low crop harvesting" is 40 yuan/mu; ② The subsidy standard for "single tillage and returning farmland" operation is 40 yuan/mu; ③ The subsidy standard for "low crop harvesting+tillage and returning to the field" operation is 80 yuan/mu.	Agricultural machinery service entities (agricultural machinery professional cooperatives, agricultural production enterprises, and family farms) implementing mechanized straw returning operations in Wenchang City
Mulching	1.Jilin Provincial Agriculture Commission and Jilin Provincial Department of Finance," Implementation Opinions on Accelerating the Promotion of Straw Covering and Returning Protective Tillage Technology to Promote the Quality of Farmland and the 'Green Growth ' of Ecological Tillage Benefits"	30 yuan/mu	Subsidies will be provided for the use of straw mulching and returning to the field for no tillage seeding operations or high stubble straw mulching and returning to the field for no tillage seeding operations
Grassing	1. Henan Provincial Department of Agriculture and Rural Affairs, Henan Provincial Finance	200 yuan/mu	Large scale alfalfa planting in tidal flats
	2.Inner Mongolia Baotou City Agriculture, Ministry of Finance,"Guiding Opinions on the Implementation of High Yield and High Quality Alfalfa Demonstration Construction Projects in 2013"	600 yuan/mu	Planting alfalfa in concentrated contiguous areas of over 3000 acres

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Strip cropping	1. People's Government of Longquan City, Zhejiang Province, "Notice of Zhejiang Provincial Department of Agriculture and Rural Affairs and Zhejiang Provincial Department of Finance on Launching and Implementing the Dynamic Subsidy Policy for Provincial Scale Grain Production in 2023"	A direct subsidy of 120 yuan per mu will be given based on the intercropping area of the "three gardens", and a dynamic scale subsidy of 20 yuan per mu.	Planters who intercrop the same dry grain crop in orchards, tea gardens, and young sparse forests, with a contiguous area of more than 50 acres and an intercropping area ratio of more than 50%
	2. Linhai Municipal People's Government	150 yuan/mu	Subsidies for intercropping the same dry grain crop in three orchards, covering an area of 50 acres and more than 50% of the intercropping area. The subsidy covers orchards, mulberry orchards, or young sparse forests.
Contour farming	1. Yanchuan County Agriculture and Rural Bureau, draft decision on "Implementation Plan for Supporting the Development of Sericulture Industry in Weak Industry Villages"	1. The plot that was originally an old terraced field will receive a subsidy of 500 yuan per mu for planting mulberry trees after renovation. 2. For gentle slopes with a slope of less than 10 degrees, a subsidy of 1100 yuan per mu will be provided for planting mulberry trees in terraced fields; 3. For steep plots with a slope of more than 10 degrees, a subsidy of 1800 yuan per acre will be provided for planting mulberry trees in terraced fields	1. The plot that was originally an old terraced field has been transformed and planted with mulberry trees; 2. Gentle slopes with a slope of less than 10 degrees, leveled as terraced fields for planting mulberry trees; 3. Steep slopes with a slope of more than 10 degrees should be leveled and terraced for planting mulberry trees.
	2. Agriculture and Rural Affairs of Qingshui County, Finance of Qingshui County, "Implementation Plan for the 2021 Rural Characteristic Breeding Industry Enhancement Action in Qingshui County", and" Implementation Plan for the Special Rectification of Abandoned Land in Qingshui County"	100 yuan/mu/year	Farmers who plant crops such as grain in newly constructed terraced fields in 2019 and beyond will be rewarded for three consecutive years starting from 2021,
Sustainable crop rotation	1. Heilongjiang Provincial Department of Agriculture and Rural Affairs, "Notice of Heilongjiang Province on Applying for and Implementing the Pilot Program of New Farmland Rotation in 2022"	150 yuan/mu	Farmers engaged in corn soybean rotation
	2. Wuyuan County Agriculture and Rural Bureau, "Wuyuan County 2022 Rice and Oil Cropping Implementation Plan"	100 yuan/mu, supplemented with rapeseed seeds, slow-release compound fertilizer, boron fertilizer, and pesticides in physical and chemical forms	Implement ecological and environmental subsidies for rapeseed farmers engaged in rice oil rotation

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Vegetated buffer strips	1. Meishan Management Committee of Tianfu New Area, Sichuan	2000 yuan/mu	Owners within 500 meters along the banks of 22 rivers included in the assessment of the new district's river chief system, with a land transfer area of more than 10 acres, engaged in the production of grain, oil, vegetables, and fruits, and who adopted ecological buffer demonstration zone technology in the same year, can apply for this special financial subsidy.
	2. Jiangsu Provincial Department of Finance and Department of Ecology and Environment," Notice on Issuing Subsidy Funds for 2022 Jiangsu Province Ecological Security Buffer Zone Demonstration Projects (Su Cai Zi Huan [2022] No. 36)"	Provincial funding subsidy of 4.05 million yuan	Ecological design and construction of the ecological security buffer zone of the Fengpei Canal in Peixian County
Hedgerows	1. Shandong Provincial Department of Finance and Shandong Provincial Department of Natural Resources, "Shandong Province Forest Ecological Compensation Measures (Trial)"	⩽ 400 yuan/mu	New afforestation, after reviewing the afforestation map results at the provincial level, will be compensated by the provincial finance according to the actual area
	2. Wucheng District Agriculture and Rural Bureau," Notice on Issuing Implementation Opinions on Subsidies for One Million Mu of Newly Added Land Greening Funds in Wucheng District"	Woody oilseed afforestation: 2000 yuan/mu. Economic afforestation: 2000 yuan/mu. Other tree species afforestation: 1-2 year old seedlings afforestation: 1800 yuan/mu; Afforestation of large seedlings with a diameter of 3 cm or more at breast height and over 3 years old: 3000 yuan/mu; Nursery planting will not be subsidized.	Afforestation units and individuals who meet the requirements of adding one million acres of land greening in Wucheng District
Reservoir tillage	N/A	N/A	N/A

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Retention ditches	1. Agriculture and Rural Bureau of Zhuji City, "Implementation Plan for the Construction of Ecological Interception Ditches for Nitrogen and Phosphorus in Farmland in Zhuji City in 2023"	The municipal government has arranged a fund of 920000 yuan, of which 500000 yuan will be used for the planning, design, construction, bidding and audit of the Qianqiu Ancient Bridge nitrogen and phosphorus ecological interception ditch in Jinan Street, 330000 yuan will be used for the relevant expenses of the nitrogen and phosphorus ecological interception ditch in Wuzhishan Village, Anhua Town, 60000 yuan will be used for the daily maintenance of 12 existing ditches, and 30000 yuan will be used for the water quality testing of 12 existing ditches. After the new ditch passes the joint acceptance at the municipal and town levels, a full compensation will be given based on the actual investment amount completed during the audit, with a maximum subsidy fund of no more than 500000 yuan. The management and maintenance costs of existing ditches and canals shall be assessed by the Municipal Agricultural Technology Promotion Center in conjunction with the town (street) where they are located. After passing the assessment, the corresponding ditch management and maintenance subjects shall be rewarded with a standard reward of 5000 yuan per piece.	The government unifies the construction of nitrogen and phosphorus ecological interception ditches
	2. Suichang County Agriculture and Rural Bureau, Suichang County Finance Bureau, "2020 Suichang County Agricultural Nitrogen and Phosphorus Ecological Interception Ditch Construction Plan"	Provincial supplementary fund of 240000 yuan	The government unifies the construction of nitrogen and phosphorus ecological interception ditches
Drainage ditches	1.Haifu Town, Qidong City," Implementation Opinions on Accelerating High Standard Rural Water Conservancy Construction"	For villages that implement permanent drainage pipeline laying, a fixed lump sum subsidy of 10 yuan/meter and 300 yuan/manhole will be given according to the acceptance length after the project is completed.	The town government uniformly implements the laying of permanent drainage pipelines
Fish scale pits	1. Ninghua County Forestry Bureau," Implementation Plan for the 2020 Woody Oil Seed Demonstration Base Construction Project"	250 yuan/mu	Subsidy for the production process of expanding holes and cultivating soil (or digging fish scales) in the ecological transformation demonstration base of woody oil bearing forests

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Terracing	the Development and Reform Commission, Provincial Department of Finance, Provincial Department of Land and Resources, Provincial Department of Water Resources, Provincial Poverty Alleviation Office, Provincial Agricultural Comprehensive Development Office and other departments of Gansu Province,"Notice on the Special Plan for Terraced Field Construction in Gansu Province (2011-2015)"	The subsidy standards for the Yellow River Basin average of 400 yuan/mu and the Yangtze River Basin average of 600 yuan/mu	The main body implementing terraced field construction
Sustainable irrigation	Hebei Provincial Finance, "Implementation Plan for High Efficiency and Water saving Irrigation Project for Comprehensive Management of Overextraction of Groundwater in 2023"	150 yuan/mu	The main body that meets the implementation requirements of efficient water-saving irrigation projects
Organic fertilization	1. Ministry of Agriculture and Rural Affairs of the People's Republic of China, "Response to Proposal No. 0380 of the First Session of the 14th National People's Congress"	150-480 yuan/ton	Farmers using organic fertilizers
	2. Beijing Daxing District Agriculture and Rural Bureau and Beijing Daxing District Agricultural Service Center have issued the "Implementation Plan for the 2024 Special Transfer Payment of Agricultural and Rural Reform and Development Municipal Funds - Implementation of Commodity Organic Fertilizer Subsidy Project in advance"	480 yuan/ton.The annual limit is 1 ton per acre.	The subsidy targets agricultural production and operation entities that apply organic fertilizers within the scope of Daxing District
Planning traffic frequency	1. Ministry of Agriculture and Rural Affairs and Ministry of Finance of the People's Republic of China, "Guiding Opinions on the Implementation of Agricultural Machinery Purchase Subsidies from 2021 to 2023"	Subsidies for the purchase of agricultural machinery from the central government will be fixed. The amount of subsidies for each grade of agricultural machinery products shall not exceed 30% of the average sales price of this file product in the province in the past three years, and the subsidy quota of field operation machinery such as cultivation and harvesting of main crops and plant protection in key blood control areas shall not exceed 50%.	Subsidy targets individuals and agricultural production and operation organizations engaged in agricultural production

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
	2.Wuhan Agriculture and Rural Bureau, "Notice of Wuhan city on Issuing the Implementation Plan for Agricultural Machinery Purchase and Application Subsidies in Wuhan from 2023 to 2025"	Determine a unified subsidy ratio for products of the same type and grade. Adopt a fixed proportion subsidy, with a maximum subsidy limit of 50% of the product's selling price.	Subsidies for agricultural machinery
Heavy traffic control	1. Agriculture and Rural Bureau of Gangbei District, Guigang City, Guangxi Zhuang Autonomous Region, "Implementation Plan for Subsidies for Mechanized Production of Sugarcane in Gangbei District from 2020 to 2022"	Mechanized deep plowing (deep loosening) costs 30 yuan/mu, powder ridge land preparation costs 80 yuan/mu, rotary tillage costs 20 yuan/mu, row planting costs 10 yuan/mu, joint planting costs 50 yuan/mu, intermediate tillage and soil cultivation costs 25 yuan/mu, plant protection costs 5 yuan/mu/time, inter row leaf stripping costs 20 yuan/mu, joint machine charging 234 yuan/mu (or 45 yuan/ton), cutting and stacking machine charging 100 yuan/mu, cutting and paving machine charging 60 yuan/mu, land collection and leaf stripping costs 50 yuan/mu (or 10 yuan/ton), sugarcane leaf crushing and returning to the field costs 20 yuan/mu, and machine harvesting and transportation costs 15 yuan/ton.	service organizations and individuals engaged in sugarcane mechanization operations and the creation of efficient sugarcane harvesting bases
Reduction of grazing intensity	1. Gansu Provincial Department of Agriculture and Animal Husbandry, "Implementation Opinions on the New Round of Grassland Ecological Protection Subsidy and Reward Policies in Gansu Province (2016-2020)"	The annual subsidy standards for grazing prohibition in the three major regions of the province are: 21.67 yuan per mu in the Qinghai Tibet Plateau region, 4.62 yuan per mu in the Loess Plateau region, and 3.87 yuan per mu in the western desert region. The annual reward standards for grass and animal balance in the three major regions of the province are: 3.35 yuan per mu in the Qinghai Tibet Plateau region, 2.67 yuan per mu in the Loess Plateau region, and 2.17 yuan per mu in the western desert region.	Gansu Province provides subsidies to farmers and herdsmen who have implemented grazing bans and animal husbandry. For the available grasslands outside the grazing prohibition areas, Gansu Province will provide grass and livestock balance rewards to farmers and herdsmen who fulfill their obligations to balance grass and livestock and complete annual livestock reduction tasks.
	2. Ministry of Agriculture and Ministry of Finance, "Guiding Opinions on the Implementation of the New Round of Grassland Ecological Protection Subsidy and Reward Policies (2016-2020)"	A grazing ban subsidy of 7.5 yuan per acre per year is given, and a grass and livestock balance reward of 2.5 yuan per acre per year is given	Herdsmen who implement grazing bans and animal husbandry, and fulfill their obligation to balance grass and livestock

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Grazing management	1. National Forestry and Grassland Administration and Ministry of Agriculture and Rural Affairs,""Notice on Implementing the Third Round of Grassland Ecological Protection Subsidy and Reward Policies and Effectively Doing a Good Job in Grassland Prohibition and Grassland Livestock Balance"	Grazing ban subsidy of 7.5 yuan/mu, grass and livestock balance reward of 2.5 yuan/mu	Business entities that fulfill grazing bans or balance requirements and are included in the implementation scope of grassland compensation policies
Green manure	1. Qingpu District Agriculture and Rural Committee and District Finance Bureau of Shanghai, "Implementation Rules for Subsidies for Protection and Improvement of Farmland Quality in Qingpu District"	According to the planting quality of green fertilizer, the maximum subsidy is not more than 250 yuan/mu. Green fertilizer seed a free supply: according to red flowers and grass 5 jin/mu, green broad beans 15 jin/mu, landscape rape 1.5 jin/mu	Landscape rapeseed planted in contiguous fields within beautiful rural areas and plowed during the late flowering period can enjoy green manure subsidy policies.
Agroforestry	1. Xingtai Municipal Government," Implementation Opinions on Accelerating Agricultural and Forestry Integrated Management"	100 yuan/mu	Farmers in the Fuxi area mainly focus on developing timber forests and promoting planting models such as intercropping between forests and grains and between forests and vegetables; Farmers in the Heilonggang Basin mainly focus on developing jujube and promoting planting models such as jujube grain intercropping and jujube cotton intercropping.
Nutrient management plan	1. Ministry of Agriculture and Rural Affairs, Ministry of Finance, "Notice on Implementing the 2019 Livestock and Poultry Manure Resource Utilization Project"	The central government's subsidy funds are generally limited to 35 million yuan for project counties with a pig equivalent (calculated based on the number of live pigs and cows in stock, where one cow is equivalent to five pigs) of less than 500000 heads; For project counties with a pig yield of 510000 to 700000 heads, the cumulative subsidy limit is 40 million yuan; For project counties with a pig yield of 71-990000 heads, the cumulative subsidy limit is 45 million yuan; For project counties with a pig yield of over 1 million, the cumulative subsidy limit is 50 million yuan. Each provincial capital independently determines the subsidy methods, targets, and standards based on the scale of the central government's subsidy funds and the actual situation of local livestock and poultry manure resource utilization.	The animal husbandry counties determined by the Ministry of Agriculture and Rural Affairs, among which the pig transfer out counties are based on the pig transfer out counties in 2018. Animal husbandry counties that have already carried out whole county governance will no longer be supported repeatedly

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Nutrient management plan	2. Yangdong District Agriculture and Rural Bureau of Yangjiang City, "pilot project of green planting and breeding circular agriculture"	The reward standard for composting manure is 89 yuan/mu; The subsidy standard for biogas slurry fertilizer is 89 yuan/mu.	In 2022, Yangdong District of Yangjiang City will complete the pilot tasks of collecting manure, treating manure, transporting fertilizers, and applying them to the fields as required, and pass the acceptance of the green planting and breeding circular agriculture pilot project as the main implementation entity.
Precision fertilisation	1. Yueqing Agriculture and Rural Bureau and Yueqing Finance Bureau, "Implementation Plan for the "Three New" Pilot Work of Reducing Fertilizer Consumption and Increasing Efficiency in Yueqing City in 2023"	(1) Demonstration household construction: The rice "three new" technology demonstration party will be given a subsidy of 5000 yuan/person for the construction of the demonstration party. For every 100 mu increase, the subsidy will increase by 10000 yuan. The demonstration party of fertilizer quota system will be given a subsidy of 5000 yuan per unit for construction. Organic substitution demonstration party will be given a subsidy of 5000 yuan per demonstration party for construction. The demonstration party for integrated water and fertilizer will be given a subsidy of 10000 yuan per unit for construction. (2) Drone fertilization operations use drones to apply slow-release fertilizers, organic water-soluble fertilizers, microbial fertilizers and other new products, and comply with the main recommended formula released by the Agriculture and Rural Bureau of Yueqing City that year. Subsidies will be given at a rate of 5 yuan/acre per application; If using multispectral drones for precise fertilization, a subsidy of 10 yuan/mu per application will be provided. The subsidy area shall not exceed 30000 mu per time.	(1) Subsidies for demonstration party construction. Agricultural cooperatives or large agricultural households are the demonstration implementation entities and can choose to apply for subsidy from the demonstration party according to the construction requirements. (2) Subsidy for drone fertilization operations. Subsidies for fertilization operations will be provided to social service organizations (including professional cooperatives, plant protection service limited companies, family farms, agricultural service enterprises, etc.) that use plant protection drones to provide unified prevention and control services for major grain and oil crops such as rice and wheat planted throughout the city.
	2. Ninghua County Forestry Bureau, "Implementation Plan for the 2020 Woody Oil Seed Demonstration Base Construction Project"	135 yuan/mu	Subsidies for scientific fertilization production in demonstration bases for ecological transformation of woody oil bearing forests
Regenerative agriculture	1. Ministry of Finance, Ministry of Agriculture and Rural Affairs, "Management Measures for Subsidies for Agricultural Construction"	Central finance: 92 billion yuan will be allocated in 2023 to support the construction, renovation, and upgrading of 80 million mu of high standard farmland. Shandong Province: 1950 yuan/mu; Anhui Province: 2500 yuan/mu	Small farmers, family farms, farmer cooperatives, professional large households, agricultural enterprises and units, and rural collective economic organizations can all receive high standard farmland subsidies. However, the amount of standard subsidies and high standard farmland subsidies set by each region varies.

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Regenerative agriculture	2. Dinghai District, Zhoushan City, Zhejiang Province,"Subsidy policies for comprehensive land improvement and ecological restoration projects"	The indicator of supplementary cultivated land quantity is 150000 yuan/mu; Supplement the "drought to water" quota of 150000 yuan/mu; The grain production capacity index is 10000 yuan per mu per 100 kilograms; Supplementing first-class standard farmland with 70000 yuan/mu and second-class standard farmland with 40000 yuan/mu	All comprehensive land improvement and ecological restoration projects that complete annual construction tasks as planned can receive subsidies
	1. Ministry of Finance and National Forestry and Grassland Administration, "Management Measures for Funds for Forestry and Grassland Reform and Development"	The deadline and standards for the new round of subsidies for returning farmland to forests and grasslands are: a subsidy of 1200 yuan per mu of farmland to be returned to forests, distributed in three installments within five years, with 500 yuan in the first year, 300 yuan in the third year, and 400 yuan in the fifth year; The subsidy for returning farmland to grassland is 850 yuan per acre, which will be issued in two installments within three years, with 450 yuan in the first year and 400 yuan in the third year. The subsidy period and standards for the extension period of the new round of returning farmland to forests and grasslands are: 500 yuan per mu of returned farmland to forests, issued in five installments, with an annual subsidy of 100 yuan; The subsidy for returning farmland to grassland is 300 yuan per acre, distributed in three installments, with an annual subsidy of 100 yuan. The subsidy for returning farmland to ecological forests for nurturing and returning farmland is 100 yuan per acre, which will be issued in five installments starting from the year after the policy expires, with an annual subsidy of 20 yuan.	Farmers returning farmland to forests and grasslands. Mountainous and hilly areas; Soil erosion is serious, the grain yield is low and unstable, the slope is more than 6 degrees, farmers have contracted or extended the contract of sloping land.

Hungary

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Non inversion tillage	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Non-rotational tillage (minimum tillage, zero tillage, direct seeding). The use of non-rotational tillage on at least 50% of the cultivated area with reduced use of herbicides.
No-till	N/A	N/A	N/A
Strip-till	N/A	N/A	N/A

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Cover crops	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Covering arable land. Provision shall be made for the continuous covering of the soil in the year following the reference year the following year, but at least until 28 February of the year following the year in question. The autumn-sown crop or cover crop shall be sown 15 days after the harvest of the main crop. If this is not possible the field shall be maintained for 15 days before the scheduled sowing.
	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Covering orchards (and vineyards) by maintaining perennial crops or by grassing. In the case of the practice, the inter-row cover of perennial crops or grassland must be in the field for the whole of the year in question. The only exception to this is in the year of planting, when the planting of the perennial cover crops takes place by 1 May.
Crop residue incorporation	N/A	N/A	N/A
Mulching	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Soil cover for orchards in areas with slopes below 12% by mulching or the cultivation of annual cover crops. A continuous ground cover is required in all inter-rows. In the case of mulching, from 1 May to 30 September if annual crops are sown throughout the year.
Grassing	N/A	N/A	N/A
Strip cropping	N/A	N/A	N/A
Contour farming	N/A	N/A	N/A
Sustainable crop rotation	N/A	N/A	N/A
Vegetated buffer strips	N/A	N/A	N/A
Hedgerows	N/A	N/A	N/A
Reservoir tillage	N/A	N/A	N/A
Retention ditches	N/A	N/A	N/A
Drainage ditches	N/A	N/A	N/A
Fish scale pits	N/A	N/A	N/A
Terracing	N/A	N/A	N/A

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Sustainable irrigation	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Application of micro-irrigation technologies. Use of micro-irrigation technologies on at least 50% of the plantation area (orchards/vineyards).
Organic fertilization	N/A	N/A	N/A
Planning traffic frequency	N/A	N/A	N/A
Heavy traffic control	N/A	N/A	N/A
Reduction of grazing intensity	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Shepherding or intermittent grazing: it is met if no more than 50% of the area designated for intermittent grazing is grazed by an animal in a given time window, provided that grazing on any one section does not exceed 12 days. The minimum number of livestock units grazed per hectare in the areas concerned by the practice is 0,2 and the presence of own livestock is compulsory.
Grazing management	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Conservation of grasslands: The grasslands cutting, ploughing or conversion to other uses is prohibited.
	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Mowing of extensive grassland at least once a year: The practice is only optional in non-Natura 2000 grassland areas. It can be chosen together with "use of alternating scythe only"practice.
Green manure	N/A	N/A	N/A
Agroforestry	N/A	N/A	N/A
Nutrient management plan	N/A	N/A	N/A
Precision fertilisation	N/A	N/A	N/A
Regenerative agriculture	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Crop diversification: The cultivation of a defined number and proportion of different crops in a given year in relation to the size of the farmer's arable area.

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Regenerative agriculture	CAP Agro-ecological Programme, Ministry of Agriculture	To qualify for the subsidy, a farm log book must be kept and submitted electronically. min 61-max 105 EUR/ha	Use of microbiological products and/or soil conditioners and/or biological agents in plantations At least 50% of the planted area should be treated with microbiological products/ conditioners/agents for soil treatment, to break down plant residues accumulated in the inter-row zone, N-fixation or for plant management.

Italy

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Non inversion tillage	CAP, RDP measure SRA3: techniques for reduced tillage, Action 3.2	250-600 €/ha	activated in 10/21 regions in IT. Each Region adopts different conditions, such as minimum farm surface with adoption, or specific crops, or NVZ areas, or mountain/hills, or low SOM content...
No-till	CAP, RDP measure SRA3: techniques for reduced tillage, Action 3.1	200-650 €/ha	activated in 12/21 regions in IT. Each Region adopts different conditions, such as minimum farm surface with adoption, or specific crops, or NVZ areas, or mountain/hills, or low SOM content...
Strip-till	CAP, RDP measure SRA3: techniques for reduced tillage, Action 3.2	200-650 €/ha	activated in 12/21 regions in IT. Each Region adopts different conditions, such as minimum farm surface with adoption, or specific crops, or NVZ areas, or mountain/hills, or low SOM content...
Cover crops	CAP, RDP measure SRA6: cover crops action 6.1	150-300 €/ha	activated in 7/21 regions in IT. Each Region adopts different conditions, such as altitude and contemporary adhesion to other actions
Crop residue incorporation	N/A	N/A	N/A
Mulching	N/A	N/A	N/A
Grassing	CAP, RDP measure SRA7: conversion of arable to permanent grassland	250-970 €/ha	activated in 2/21 regions in IT
Strip cropping	N/A	N/A	N/A
	N/A	N/A	N/A

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Contour farming	N/A	N/A	N/A
Sustainable crop rotation	it is part of the GAEC, therefore it is mandatory to access CAP direct payments		
Vegetated buffer strips	CAP, RDP measure SRA10: ecological infrastructure, action 10.1.1	600-800 €/ha	activated in 6/21 regions in IT
Hedgerows	CAP, RDP measure SRA10: ecological infrastructure, action 10.1.2	600-800 €/ha	activated in 6/21 regions in IT
Reservoir tillage	N/A	N/A	N/A
Retention ditches	N/A	N/A	N/A
Drainage ditches	N/A	N/A	N/A
Fish scale pits	N/A	N/A	N/A
Terracing	N/A	N/A	N/A
Sustainable irrigation	CAP,RDP measure SRA02: sustainable use of water	100-820 €/ha	activated in 6/21 regions in IT
Organic fertilization	N/A	N/A	N/A
Planning traffic frequency	N/A	N/A	N/A
Heavy traffic control	N/A	N/A	N/A
Reduction of grazing intensity	N/A	N/A	N/A
Grazing management	CAP, RDP measure SRA08: permanent grassland and pasture management	+40 €/ha if pastoral plan	activated in 12/21 regions in IT but only 1 requires a pastoral plan
Green manure	CAP, RDP measure SRA6: cover crops action 6.1	150-300 €/ha	activated in 7/21 regions in IT. Each Region adopts different conditions, such as altitude and contemporary adhesion to other actions
Agroforestry	CAP, RDP measure SRA28: forestry, reforestation and agroforestry	440-2000 €/ha	activated in 6/21 regions in IT
Nutrient management plan	CAP, RDP measure SRA20: sustainable use of nutrients	80-300 €/ha	activated in 3/21 regions in IT
Precision fertilisation	CAP, RDP measure SRA24: precision agriculture	72-470 €/ha	activated in 8/21 regions in IT
Regenerative agriculture	N/A	N/A	N/A

Spain

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Non inversion tillage	1. CAP, Enhanced Conditionality GAEC 5: Minimal tillage management, reducing the risk of soil degradation and erosion, including taking into account slope inclination.	Do not till the land in the direction of the steepest slope when, in cultivated areas, the average slope is greater than or equal to 10%, unless the actual slope of the area is compensated by terraces or beds. Plots of herbaceous and woody crops with an area equal to or less than one hectare are exempt. The practice of inter-vine tilling is permitted in vineyard areas as a traditional practice. Tilling may be carried out in the direction of the steepest slope when tilling crosswise could pose a risk of the machinery overturning.	Penalty on direct payments for non-compliance with obligations.
No-till	1. CAP, Eco-scheme P4: Direct sowing on dry farmland (Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 47.67 €/ha for thresholds ≤ 70 ha, and 61.91 €/ha for thresholds > 70 ha. With perenniality: 72.67 €/ha for thresholds ≤ 70 ha, and 36.91 €/ha for thresholds > 70 ha. Farmers practicing direct sowing annually receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	– To comply with the no-till practice, the farmer must meet the following requirements on at least 40% of the cultivated land corresponding to each type of surface for which this practice is requested: a) No plowing operations on the soil. b) Direct sowing onto stubble and maintain it on the ground, ensuring continuous soil coverage throughout the year. c) Implementation of crop rotation on the direct sowing surface, excluding perennial species except in their planting year. Secondary crops in the same year as the main crop are considered for rotation purposes. The area declared as fallow land after a leguminous crop is not included in the rotation percentage. – Exceptions: Exceptional permission for vertical tillage may be granted by the competent authority, provided stubble maintenance is ensured throughout the year.
	2. CAP, Eco-scheme P4: Direct sowing on humid dry farmland.	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 70.52 €/ha for thresholds ≤ 30 ha, and 49.36 €/ha for thresholds > 30 ha. With perenniality: 95.52 €/ha for thresholds ≤ 30 ha, and 74.36 €/ha for thresholds > 30 ha. Farmers practicing direct sowing annually receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
No-till	3. CAP, Eco-scheme P4: Direct sowing on irrigated farmland (Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 139.53 €/ha for thresholds ⩽ 25 ha, and 97.67 €/ha for thresholds > 25 ha. With perenniality: 164.53 €/ha for thresholds ⩽ 25 ha, and 122.67 €/ha for thresholds > 25 ha. Farmers practicing direct sowing annually receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	
	4. CAP, Eco-scheme P4: Direct sowing on dry farmland (Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 75.67 €/ha for thresholds ⩽ 70 ha, and 64.91 €/ha for thresholds > 70 ha. With perenniality: 100.67 €/ha for thresholds ⩽ 70 ha, and 89.91 €/ha for thresholds > 70 ha. Farmers practicing direct sowing annually receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	
	5. CAP, Eco-scheme P4: Direct sowing on irrigated farmland (Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 219.53 €/ha for thresholds ⩽ 25 ha, and 177.67 €/ha for thresholds > 25 ha. With perenniality: 244.53 €/ha for thresholds ⩽ 25 ha, and 202.67 €/ha for thresholds > 25 ha. Farmers practicing direct sowing annually receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	
	6. CAP, Enhanced Conditionality GAEC 9: Prohibition of converting or ploughing permanent grasslands declared as environmentally sensitive permanent pastures in Natura 2000 areas.	Penalty on direct payments for non-compliance with obligations.	– Permanent pastures designated as environmentally sensitive, located in the areas covered by Directive 92/43/EEC and Directive 2009/147/EC, may not be converted or tilled, nor work carried out beyond that necessary for their maintenance.
Strip-till	N/A	N/A	N/A

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Cover crops	1. CAP, Eco-scheme P6: Vegetative covers in woody crops on flat terrain (slope less than 5%; Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 61.07 €/ha for thresholds ⩽ 15 ha, and 61.07 €/ha for thresholds > 15 ha. With perenniality: 86.07 €/ha for thresholds ⩽ 15 ha, and 86.07 €/ha for thresholds > 15 ha. Farmers practicing the cover for consecutive years receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	– To comply with the practice of spontaneous or seeded vegetative cover, the farmer must fulfill the following commitments: a) Annual Establishment and Maintenance: i) Farmers commit to establishing and/or maintaining vegetative cover on the field throughout the year, whether live or dried, ensuring the soil remains covered. ii) Record the "date of establishment of the vegetative cover" in the agricultural exploitation record book within one month of the specified start date. b) Minimum Duration of Vegetative Cover: i) Vegetative cover must remain alive for a minimum of four months between October 1st and March 31st, as defined by autonomous communities. ii) Autonomous communities communicate the specified duration to the Ministry of Agriculture, Fisheries, and Food. c) Mechanical Management: i) Vegetative cover management primarily through mechanical means such as mechanical mowing or clearing. ii) Prohibition of herbicides or other phytosanitary products in the herbaceous vegetative cover center. iii) Mechanical management to limit water and nutrient competition, with annual passes of mowers or mechanical clearing. Exception: For areas with terrain unsuitable for mechanical activity, maintenance may be solely through grazing. d) Cover Restoration: After mowing or clearing, cover remains must cover the initial space, ensuring soil coverage throughout the year. e) Minimum Cover Width: i) Cover should occupy at least 40% of the street width, with a minimum width of 0.5 meters. ii) For slopes ⩾ 10%, or narrow streets in woody crops, additional width requirements apply. – Exceptions and Modifications: a) Phytosanitary Application: Exceptional use of phytosanitary products allowed for pest prevention, control, or eradication, upon competent authority approval. b) Modification of Cover Duration: Autonomous communities may reduce the mandatory four-month duration based on adverse agroclimatic conditions, subject to competent authority approval. c) Surface Works: i) Surface work for sowing preparation allowed for seeded covers. ii) Exceptional shallow surface maintenance permitted, ensuring no soil structure modification. iii) Autonomous communities define and authorize exceptional maintenance works based on agronomic characteristics.

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Cover crops	2. CAP, Eco-scheme P6: Vegetative covers in woody crops on medium slope terrain (slope equal to or greater than 5% and less than 10%; Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 113.95 €/ha for thresholds ⩽ 15 ha, and 113.95 €/ha for thresholds > 15 ha. With perenniality: 138.95 €/ha for thresholds ⩽ 15 ha, and 138.95 €/ha for thresholds > 15 ha. Farmers practicing the cover for consecutive years receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	
	3. CAP, Eco-scheme P6: Vegetative covers in woody crops on steep terrain and terraces (slope equal to or greater than 10%; Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 165.17 €/ha for thresholds ⩽ 15 ha, and 115.62 €/ha for thresholds > 15 ha. With perenniality: 190.17 €/ha for thresholds ⩽ 15 ha, and 140.62 €/ha for thresholds > 15 ha. Farmers practicing the cover for consecutive years receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	
	4. CAP, Eco-scheme P6: Vegetative cover in woody crops on flat terrain (slope less than 5%; Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 101.07 €/ha for thresholds ⩽ 15 ha, and 101.07 €/ha for thresholds > 15 ha. With perenniality: 126.07 €/ha for thresholds ⩽ 15 ha, and 126.07 €/ha for thresholds > 15 ha. Farmers practicing the cover for consecutive years receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Cover crops	5. CAP, Eco-scheme P6: Vegetative covers in woody crops on medium slope terrain (slope equal to or greater than 5% and less than 10%; Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 177.95 €/ha for thresholds ≤ 15 ha, and 177.95 €/ha for thresholds > 15 ha. With perenniality: 202.95 €/ha for thresholds ≤ 15 ha, and 202.95 €/ha for thresholds > 15 ha. Farmers practicing the cover for consecutive years receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	
	6. CAP, Eco-scheme P6: Vegetative covers in woody crops on steep terrain and terraces (slope equal to or greater than 10%; Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 253.17 €/ha for thresholds ≤ 15 ha, and 203.32 €/ha for thresholds > 15 ha. With perenniality: 278.17 €/ha for thresholds ≤ 15 ha, and 228.62 €/ha for thresholds > 15 ha. Farmers practicing the cover for consecutive years receive a fixed supplement of 25 euros per hectare. Payment of the supplement is conditional on continuing the practice on the same plots.	
	7. CAP, Enhanced Conditionality GAEC 6: Minimum soil cover to prevent bare soils during the most sensitive periods.	Penalty on direct payments for non-compliance with obligations.	
Crop residue incorporation	1. CAP, Eco-scheme P7: Inert covers in woody crops on flat terrain (slope less than 5%; Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 61.07 €/ha for thresholds ≤ 15 ha, and 61.07 €/ha for thresholds > 15 ha. With perenniality: 86.07 €/ha for thresholds ≤ 15 ha, and 86.07 €/ha for thresholds > 15 ha.	– To comply with the practice of inert coverings of pruning residues, the farmer must fulfill the following commitments: a) Shred and deposit pruning residues as inert coverings. b) Ensure a minimum coverage area of 40% of the free width of the crown projection with pruning residues. c) Prohibit phytosanitary treatments on the covered surface. d) Allow shallow maintenance works if they don't alter soil structure or cover disappearance. – Exceptions: a) Prohibit practice if pest issues are identified in woody crops to prevent pest spread. b) In cases of authorized phytosanitary treatments due to pest detection, practice suspension is required if problems persist. – Management: a) If pests are declared on the residues, management will follow regulations for each type of pest. b) Phytosanitary treatments, residue removal, or burial post-treatment may be permitted based on specific circumstances and regulatory guidance.

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Crop residue incorporation	2. CAP, Eco-scheme P7: Inert covers in woody crops on medium slope terrain (slope equal to or greater than 5% and less than 10%; Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 113.95 €/ha for thresholds ≤ 15 ha, and 113.95 €/ha for thresholds > 15 ha. With perenniality: 138.95 €/ha for thresholds ≤ 15 ha, and 138.95 €/ha for thresholds > 15 ha.	
	3. CAP, Eco-scheme P7: Inert covers in woody crops on steep terrain and terraces (slope equal to or greater than 10%; Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 165.17 €/ha for thresholds ≤ 15 ha, and 115.62 €/ha for thresholds > 15 ha. With perenniality: 190.17 €/ha for thresholds ≤ 15 ha, and 140.62 €/ha for thresholds > 15 ha.	
	4. CAP, Eco-scheme P7: Inert covers in woody crops on flat terrain (slope less than 5%; Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 101.07 €/ha for thresholds ≤ 15 ha, and 101.07 €/ha for thresholds > 15 ha. With perenniality: 126.07 €/ha for thresholds ≤ 15 ha, and 126.07 €/ha for thresholds > 15 ha.	
	5. CAP, Eco-scheme P7: Inert covers in woody crops on medium slope terrain (slope equal to or greater than 5% and less than 10%; Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 177.95 €/ha for thresholds ≤ 15 ha, and 177.95 €/ha for thresholds > 15 ha. With perenniality: 202.95 €/ha for thresholds ≤ 15 ha, and 202.95 €/ha for thresholds > 15 ha.	
	6. CAP, Eco-scheme P7: Inert covers in woody crops on steep terrain and terraces (slope equal to or greater than 10%; Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 253.17 €/ha for thresholds ≤ 15 ha, and 203.32 €/ha for thresholds > 15 ha. With perenniality: 278.17 €/ha for thresholds ≤ 15 ha, and 228.62 €/ha for thresholds > 15 ha.	

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Mulching	N/A	N/A	N/A
Grassing	N/A	N/A	N/A
Strip cropping	N/A	N/A	N/A
Contour farming	N/A	N/A	N/A
Sustainable crop rotation	1. CAP, Eco-scheme P3: Crop rotation with improving species on dry farmland (Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 47.67 €/ha for thresholds ⩽ 70 ha, and 61.91 €/ha for thresholds > 70 ha. With perenniality: 72.67 €/ha for thresholds ⩽ 70 ha, and 36.91 €/ha for thresholds > 70 ha.	– The farmer must meet the following requirements to comply with the practice of crop rotation with improving species: a) Crop rotation: i) At least 50% of the cultivated land must present a different crop each year than the previous crop. ii) When there is a secondary crop in the same year as the main crop, it will be considered for rotation purposes. iii) Land declared as fallow after a leguminous crop will not count towards the rotation percentage. iv) Exceptions: · Rotation percentage may be reduced to 25% for farms with over 25% perennial species. · Reduction based on justified adverse agroclimatic conditions. b) Soil-Improving Species: i) At least 10% of the cultivated land area must be occupied by specified soil-improving species. ii) Leguminous plants must represent at least 5% of the area. iii) Legumes may be used as green manure, not reaching full production, and must remain on the ground until at least the beginning of flowering. c)Fallow Land: i) Fallow land must not exceed 20% of the declared cultivated land area, except in specific cases. ii) In regions with an average rainfall of 400 mm or less, fallow land can reach up to 40%. iii) If fallow land is seeded, limits can increase by 10 percentage points. – Exceptions: Farms with land area ⩽ 10 hectares: i) Can opt for crop rotation or diversification. ii) Main crop cannot exceed 75% of the cultivated land area. These small farms are exempt from the requirement for improving species and fallow land limits. – Perennial species: a) Area planted with perennial species is eligible for aid but not counted towards rotation percentage, except for the current year's planting. b) Asparagus is considered a perennial species.
	2. CAP, Eco-scheme P3: Crop rotation with improving species on humid dry farmland.	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 70.52 €/ha for thresholds ⩽ 30 ha, and 49.36 €/ha for thresholds > 30 ha. With perenniality: 95.52 €/ha for thresholds ⩽ 30 ha, and 74.36 €/ha for thresholds > 30 ha.	

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Sustainable crop rotation	3. CAP, Eco-scheme P3: Crop rotation with improving species on irrigated farmland (Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 139.53 €/ha for thresholds ≤ 25 ha, and 97.67 €/ha for thresholds > 25 ha. With perenniality: 164.53 €/ha for thresholds ≤ 25 ha, and 122.67 €/ha for thresholds > 25 ha.	
	4. CAP, Eco-scheme P3: Crop rotation with improving species on dry farmland (Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 75.67 €/ha for thresholds ≤ 70 ha, and 64.91 €/ha for thresholds > 70 ha. With perenniality: 100.67 €/ha for thresholds ≤ 70 ha, and 89.91 €/ha for thresholds > 70 ha.	
	5. CAP, Eco-scheme P3: Crop rotation with improving species on irrigated farmland (Balearic Islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) Without perenniality: 219.53 €/ha for thresholds ≤ 25 ha, and 177.67 €/ha for thresholds > 25 ha. With perenniality: 244.53 €/ha for thresholds ≤ 25 ha, and 202.67 €/ha for thresholds > 25 ha.	
	6. CAP, Enhanced Conditionality GAEC 7: Crop rotation on arable land except for crops under water.	Penalty on direct payments for non-compliance with obligations.	– Carry out crop rotation on all plots of the farm except plots cultivated with multi-annual crops, at least after three years. – Carry out crop diversification on the farm. – To comply with crop diversification, the following must be taken into account: a) If the farm's farmland is greater than 10 hectares and equal to or less than 20 hectares, at least two different crops must be grown, with the majority crop accounting for more than 75% of said farmland. b) If the farm's farmland is greater than 20 hectares and equal to or less than 30 hectares, at least two different crops must be grown, with the majority crop accounting for more than 70% of said farmland. c) If the farm's farmland is greater than 30 hectares, there must be at least three different crops, without the majority accounting for more than 70% of said farmland and the two majority crops together cannot occupy more than 90% of it.

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Vegetated buffer strips	1. CAP, Enhanced Conditionality GAEC 4: Creation of buffer strips along river margins.	Penalty on direct payments for non-compliance with obligations.	– Protection strips along water courses, reservoirs, lakes and lagoons, starting from the bank, which will be located on the agricultural plot, so that the edges of these strips are parallel to the edge of the channel or mass of water, and may be occupied by riverside vegetation. These stripes will be reflected in the corresponding SIGPAC layer. – No fertilizers or phytosanitary products may be applied in the protection strip, which will be at least 5 meters wide. – In the protection strip there will be no agricultural production, except in the case of woody crops that are already established. – A vegetation cover will be maintained that may be sown or spontaneous, distinguishable from the cultivation of the adjacent agricultural land. Grazing or mowing will also be permitted. – Superficial maintenance work may be carried out to prevent the proliferation of pests and diseases that constitute a health risk for adjacent crops.
Hedgerows	1. CAP, Eco-scheme P5: Biodiversity spaces in farmland and permanent crops.	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) 46.10 €/ha	– To comply with this eco-scheme, in the case of croplands and permanent crops, including woody crops, a percentage of biodiversity spaces must be established. – Biodiversity spaces, either included within or directly adjacent to the plot declared for compliance with this eco-scheme, will include the following elements: a) Walls, ponds, Hedgerows, etc., serving as shelters and food sources for wildlife. b) Fallow lands with suitable vegetative covers. c)Biodiversity margins and islands. d) Non-harvested areas of cereals/oilseeds providing grains for birds. e) Non-harvested aromatic species providing nectar/pollen for pollinators. – Eligibility Criteria: Farmers opting for this eco-scheme must meet the active farmer requirement and receive the basic income support for sustainability. – Minimum percentages required in biodiversity spaces: a) In croplands: i) 7% of dryland area. ii) 4% of irrigated area. b) In permanent crops, 4% of the area declared under this eco-scheme. Calculation considers the larger equivalent area when different elements coexist. – Restrictions: a) No use of fertilizers or pesticides on biodiversity spaces. b) Exceptional use of pesticides permitted based on plant health authority's determination.

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Hedgerows	2. CAP, Enhanced Conditionality GAEC 8.1: Minimum percentage of agricultural area to be dedicated to non-productive features or areas.	Penalty on direct payments for non-compliance with obligations.	– On farmlands, at least one of the following options must be met: a) Minimum percentage of at least 4% of agricultural land on farms dedicated to non-productive surfaces and elements, including fallow land. b) When a farmer commits to dedicating at least 7% of their agricultural land to non-productive surfaces and elements, including fallow land, within the framework of a strengthened eco-scheme, the percentage attributed to compliance with this GAEC standard will be limited to 3%. c) Minimum percentage of at least 7% of agricultural land on farms, including catch crops and nitrogen-fixing crops, cultivated without the use of plant protection products, of which 3% will be fallow land or non-productive elements. Member States must use a weighting factor of 0.3 for catch crops.
	3. CAP, Enhanced Conditionality GAEC 8.2: Maintenance of landscape features.	Penalty on direct payments for non-compliance with obligations.	– No alteration of the topographic particularities or elements of the landscape may be made, except in the case of having express authorization from the competent authority. – Topographic particularities or landscape elements are considered to be those characteristics of the terrain such as Hedgerows... or other elements of traditional architecture that can serve as shelter for flora and fauna. – In this sense they are considered: a) Hedgerows: dense and uniform alignment of shrubs that are used to fence, delimit or cover areas and land. – Descriptive characteristics of landscape elements, maximum reference values: a) Hedgerows up to 10 m wide.
	4. CAP, Enhanced Conditionality GAEC 8.3: Prohibition of cutting Hedgerows and trees during the bird breeding and nesting season.	Penalty on direct payments for non-compliance with obligations.	– No cutting and pruning operations may be carried out on uncultivated Hedgerows and trees during the breeding and reproduction season of birds, unless expressly authorized by the environmental authority. The period from March to August will be taken as a reference, and may be modified in a justified manner by the autonomous communities.
Reservoir tillage	N/A	N/A	N/A
Retention ditches	N/A	N/A	N/A
Drainage ditches	N/A	N/A	N/A
Fish scale pits	N/A	N/A	N/A
Terracing	N/A	N/A	N/A
Sustainable irrigation	N/A	N/A	N/A
Organic fertilization	N/A	N/A	N/A
Planning traffic frequency	N/A	N/A	N/A
Heavy traffic control	N/A	N/A	N/A

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Reduction of grazing intensity	1. CAP, Eco-scheme P1: Extensive grazing on the surfaces of wet pastures.	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) 51.13 €/ha for thresholds ≤ 65 ha, and 43.51 €/ha for thresholds > 65 ha.	– Registration Requirements: The livestok farm must be registered in the General Livestock Registry (REGA) by the modification deadline of the single application. – Grazing Requirements a) Minimum Grazing Period: i) 120 days per year (continuous or discontinuous). ii) Can be reduced to 90 days for justified reasons (agroclimatic conditions) with notification to the Ministry. b) Grazing Calculation: All eligible hectares must be grazed, but not necessarily every hectare every day. – Livestock Density Requirements a) Wet Pastures: i) Minimum: 0.4 Livestock Units (LU)/hectare. ii) Maximum: 2 LU/hectare. b) Mediterranean Pastures: i) Minimum: 0.2 LU/hectare. ii) Maximum: 1.2 LU/hectare. – Special Circumstances Adjustments to livestock densities can be authorized for reasons such as natural parks, protected areas, severe climatic conditions, etc., with notification to the Ministry.
	2. CAP, Eco-scheme P1: Extensive grazing on the surfaces of Mediterranean pastures (Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) 33.70 €/ha for thresholds ≤ 95 ha, and 27.19 €/ha for thresholds > 95 ha.	
	3. CAP, Eco-scheme P1: Extensive grazing on the surfaces of Mediterranean pastures (Balearic islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) 55.70 €/ha for thresholds ≤ 95 ha, and 49.19 €/ha for thresholds > 95 ha.	
Grazing management	1. CAP, Eco-scheme P1: Extensive grazing on the surfaces of wet pastures.	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) 51.13 €/ha for thresholds ≤ 65 ha, and 43.51 €/ha for thresholds > 65 ha.	– Registration Requirements: The livestok farm must be registered in the General Livestock Registry (REGA) by the modification deadline of the single application. – Grazing Requirements a) Minimum Grazing Period: i) 120 days per year (continuous or discontinuous). ii) Can be reduced to 90 days for justified reasons (agroclimatic conditions) with notification to the Ministry. b) Grazing Calculation: All eligible hectares must be grazed, but not necessarily every hectare every day. – Livestock Density Requirements a) Wet Pastures: i) Minimum: 0.4 Livestock Units (LU)/hectare. ii) Maximum: 2 LU/hectare. b) Mediterranean Pastures: i) Minimum: 0.2 LU/hectare. ii) Maximum: 1.2 LU/hectare. – Special Circumstances Adjustments to livestock densities can be authorized for reasons such as natural parks, protected areas, severe climatic conditions, etc., with notification to the Ministry.

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Grazing management	2. CAP, Eco-scheme P1: Extensive grazing on the surfaces of Mediterranean pastures (Iberian Peninsula).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) 33.70 €/ha for thresholds ≤ 95 ha, and 27.19 €/ha for thresholds > 95 ha.	
	3. CAP, Eco-scheme P1: Extensive grazing on the surfaces of Mediterranean pastures (Balearic islands).	A 70% advance payment is made between from October 16th and November 30th, and the remaining balance divided into two installments from December 1st to June 30th of the following year. Final Unit Amounts (2023) 55.70 €/ha for thresholds ≤ 95 ha, and 49.19 €/ha for thresholds > 95 ha.	
Green manure	N/A	N/A	N/A
Agroforestry	1. CAP, Enhanced Conditionality GAEC 1: Maintenance of permanent grassland based on a ratio of permanent pasture to the agricultural area at a regional scale compared to the reference year 2018.	Penalty on direct payments for non-compliance with obligations.	– Maximum reduction of 5% compared to the reference year. – When the area does not decrease by more than 0.5% with respect to the reference permanent grassland area, the obligation will be considered fulfilled. – When the annual proportion of permanent pastures suffers a decrease equal to or greater than 5% with respect to the reference proportion, the necessary surface must be converted to permanent pastures.
Nutrient management plan	N/A	N/A	N/A
Precision fertilisation	1. CAP, Enhanced Conditionality GAEC 10: Sustainable fertilization.	Penalty on direct payments for non-compliance with obligations.	– The following obligations must be met in accordance with the calendar and conditions established in Royal Decree 1051/2022, of December 27, which establishes standards for sustainable nutrition in agricultural soils.
Regenerative agriculture	N/A	N/A	N/A
Regenerative agriculture	N/A	N/A	N/A

United Kingdom

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Non inversion tillage	Existing CS (HS3)	115£ per ha	Non-inversion (minimum tillage) machinery and shallower cultivation depths are used to reduce damage to historic and archaeological features
No-till	Sustainable Farming Incentive (SFI)	73£ per ha	No-till farming techniques are used to establish crops, so soil disturbance is reduced
	Countryside Stewardship (CS)		
Strip-till	Existing CS (HS3)	115£ per ha	Non-inversion (minimum tillage) machinery and shallower cultivation depths are used to reduce damage to historic and archaeological features
Cover crops	SFI (SAM2)	129£ per ha	There is a well-established multi-species cover crop over the winter months
		153£ to 163£ per ha	There is a well-established multi-species cover crop during the spring, summer or autumn months
	Existing CS (SW5)	203£ per ha	Maize crops are harvested by early autumn and there is a well-established cover crop during the autumn and winter months
	Existing SFI (SAM3)	382£ per ha	To provide varied root structures
Crop residue incorporation	N/A	N/A	N/A
Mulching	N/A	N/A	N/A
Grassing	Existing SFI (AHL3)	590£ per ha	There is an intact grass sward throughout the year, without tracks, compacted areas or poaching, so tussocky grass can develop
	Existing SFI (SAM3)	382£ per ha	To provide varied root structures
	Updated CS (GS9 and GS11)	676£ per ha	Wet grassland or land that is in the process of becoming wet grassland is managed to provide nesting and feeding habitat for breeding wading birds
	Updated CS (GS10 and GS12)	547£ per ha	Wet grassland or land in the process of becoming wet grassland is managed to provide roosting and feeding habitat for wintering waders and wildfowl

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Grassing	Updated CS (GS13 and GS14)	528£ per ha	Grassland or in the process of becoming grassland managed to support target habitats and species including target species such as fungi, bats, insects, birds or rare plants
	Existing CS (OR1)	187£ per ha	Improved and semi-improved permanent grassland (including arable land being reverted to permanent grassland) is converted from conventional management to organic management
	Existing CS (SW4)	707£ per ha	There is a grass buffer, with an intact sward which is managed to provide some shorter vegetation next to the crop
	Existing CS (HS2)	613£ per ha	Throughout the year, there is a continuous grass or flower mixture growing over the historic and archaeological feature
	Existing CS (HS6)	2,512£ per ha	There is a permanently vegetated grass buffer strip to protect the banks and associated historic built water-control features of designed or engineered historic water bodies
	Existing CS (WT2)	681£ per ha	There is a wide grass buffer strip surrounding a pond or next to a ditch, which is left to develop a mix of tussocky grasses, flowering plants and low scrub
Strip cropping	New	1,182£ per ha	There is a 6m to 24m wide buffer with raised ridges covered in vegetation next to a waterbody or field boundary
	Existing CS (SW4)	707£ per ha	There is a grass buffer, with an intact sward which is managed to provide some shorter vegetation next to the crop
	Existing SFI (AHL4)	515£ per ha	There is a grass buffer strip with an intact grass sward throughout the year, without tracks, compacted areas or poaching
	Existing SFI (IGL3)	235£ per ha	There is a grass buffer strip with an intact grass sward throughout the year, without tracks, compacted areas or poaching

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Strip cropping	Existing CS (WT2)	681£ per ha	There is a wide grass buffer strip surrounding a pond or next to a ditch, which is left to develop a mix of tussocky grasses, flowering plants and low scrub
	Existing CS (WT1)	311£ per ha	There is a wide grass buffer strip surrounding a pond or next to a ditch, which is left to develop a mix of tussocky grasses, flowering plants and low scrub
	Existing CS (BE1)	553£ per ha	There is a naturally regenerated grass buffer throughout the year around in-field trees on arable land, with the trees protected from damage by livestock and wild animals
	Existing CS (BE2)	295£ per ha	There is a naturally regenerated grass buffer throughout the year around in-field trees on intensive grassland, with the trees protected from damage by livestock and wild animals
	Updated CS (SW11)	742£ per ha	There is a 6m to 12m wide habitat strip next to a waterbody, with a mosaic of tussocky grasses and naturally colonised or planted tree and scrub with an open canopy
Contour farming	N/A	N/A	N/A
Sustainable crop rotation	Existing CS (OT3)	132£ per ha	Rotational land is maintained under organic management
Vegetated buffer strips	New	1,182£ per ha	There is a 6m to 24m wide buffer with raised ridges covered in vegetation next to a waterbody or field boundary
	Existing CS (SW4)	707£ per ha	There is a grass buffer, with an intact sward which is managed to provide some shorter vegetation next to the crop
	Existing SFI (AHL4)	515£ per ha	There is a grass buffer strip with an intact grass sward throughout the year, without tracks, compacted areas or poaching
	Existing SFI (IGL3)	235£ per ha	There is a grass buffer strip with an intact grass sward throughout the year, without tracks, compacted areas or poaching

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Vegetated buffer strips	Existing CS (WT2)	681£ per ha	There is a wide grass buffer strip surrounding a pond or next to a ditch, which is left to develop a mix of tussocky grasses, flowering plants and low scrub
	Existing CS (WT1)	311£ per ha	There is a wide grass buffer strip surrounding a pond or next to a ditch, which is left to develop a mix of tussocky grasses, flowering plants and low scrub
	Existing CS (BE1)	553£ per ha	There is a naturally regenerated grass buffer throughout the year around in-field trees on arable land, with the trees protected from damage by livestock and wild animals
	Existing CS (BE2)	295£ per ha	There is a naturally regenerated grass buffer throughout the year around in-field trees on intensive grassland, with the trees protected from damage by livestock and wild animals
	Existing CS (SW3)	765£ per ha	There are in-field grass strips or areas, which are managed to encourage a dense sward and a variety of grasses to grow
	Updated CS (SW11)	742£ per ha	There is a 6m to 12m wide habitat strip next to a waterbody, with a mosaic of tussocky grasses and naturally colonised or planted tree and scrub with an open canopy
Hedgerows	Existing SFI (HRW1)	5£ per 100m -one side	You understand the condition of your hedgerows and effectively plan how they can be managed to improve their condition
	Existing SFI (HRW2)	13£ per 100m -one side	Hedgerows are managed so there is a range of different heights and widths
	Existing SFI (HRW3)	10£ per 100m - both sides	Hedgerow trees are maintained or established
	new	11£ per 100m – one side	Stone-faced hedge banks are maintained to keep them in good condition

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Hedgerows	Existing CS (HS6)	2,512£ per ha	There is a permanently vegetated grass buffer strip to protect the banks and associated historic built water-control features of designed or engineered historic water bodies
Retention ditches	new	4£ per 100m – both sides	Ditches are managed so there is varied bank-side and aquatic vegetation, and wildlife habitat
	Updated CS (WT3)	38£ per 100m – both sides	Ditches are managed that either support target species of plants, birds, mammals and invertebrates or are important for delivering habitats such as wet grassland, wetland, lowland peat and floodplain meadow
	Existing CS (HS6)	2,512£ per ha	There is a permanently vegetated grass buffer strip to protect the banks and associated historic built water-control features of designed or engineered historic water bodies
Drainage ditches	New	1.17£ per square metre	Existing scrapes and gutters are maintained to have areas of bare soil, seasonal shallow water in wet habitats, and hold and transport water through the habitat
	New	4£ per 100m – both sides	Ditches are managed so there is varied bank-side and aquatic vegetation, and wildlife habitat
	Updated CS (WT3)	38£ per 100m – both sides	Ditches are managed that either support target species of plants, birds, mammals and invertebrates or are important for delivering habitats such as wet grassland, wetland, lowland peat and floodplain meadow
	Existing CS (HS6)	2,512£ per ha	There is a permanently vegetated grass buffer strip to protect the banks and associated historic built water-control features of designed or engineered historic water bodies

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Fish scale pits	new	1,241£ per ha	Features on arable land, such as sediment traps, bunds, swales and the area surrounding them, are managed to reduce runoff from rainwater and store more surface and groundwater
Terracing	new	27£ per 100m – both sides	Dry stone walls are maintained to keep them in good condition
	new	11£ per 100m – one side	Earth banks are maintained to keep them in good condition
	new	11£ per 100m – one side	Stone-faced hedge banks are maintained to keep them in good condition
Sustainable irrigation	Existing CS (HS7)	863£ per ha	Manage historic water meadows through traditional irrigation
Organic fertilization	N/A	N/A	N/A
Planning traffic frequency	Existing SFI (AHL3)	590£ per ha	There is an intact grass sward throughout the year, without tracks, compacted areas or poaching, so tussocky grass can develop
Heavy traffic control	Existing SFI (AHL3)	590£ per ha	There is an intact grass sward throughout the year, without tracks, compacted areas or poaching, so tussocky grass can develop
Reduction of grazing intensity	Existing SFI (AHL3)	590£ per ha	There is an intact grass sward throughout the year, without tracks, compacted areas or poaching, so tussocky grass can develop
	Existing SFI (IGL1)	333£ per ha	Grassland field corners or blocks are taken out of management so tussocky grass can develop
	Existing SFI (IGL2)	515£ per ha	Improved grassland is maintained so it's left to go to seed during the autumn and winter months
	Existing SFI (LIG1 and LIG2)	151£ per ha	There is grassland that produces a sward with flowering grasses and wildflowers from late spring and during the summer months, and with a variety of plant heights by autumn, with some covering of flowering grasses and wildflowers left to go to seed and tussocky grass allowed to develop

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Reduction of grazing intensity	Existing CS (GS17)	28£ per ha	Throughout the growing season, grassland is lightly grazed with cattle, or both cattle and sheep, so there is a range of shorter and taller grasses
	Updated CS (SP5)	10£ per ha	Shepherding or herding activities are undertaken to manage overgrazing and improve the quality of vegetation
Grazing management	Existing CS (SP1)	93£ per ha	Locally characteristic boundaries are kept and, where required, grazing is reintroduced
	Existing CS (SP7)	279£ per ha	Cattle grazing is introduced on land on the Isles of Scilly that is not currently grazed by cattle
	Updated CS (SP6)	59£ per ha	Cattle are grazed throughout the year to provide a varied sward structure and control scrub, bracken and coarse vegetation
	Updated CS (SP5)	10£ per ha	Shepherding or herding activities are undertaken to manage overgrazing and improve the quality of vegetation
	Existing SFI (IGL1)	333£ per ha	Grassland field corners or blocks are taken out of management so tussocky grass can develop
	Existing SFI (IGL2)	515£ per ha	Improved grassland is maintained so it's left to go to seed during the autumn and winter months
	Existing SFI (LIG1 and LIG2)	151£ per ha	There is grassland that produces a sward with flowering grasses and wildflowers from late spring and during the summer months, and with a variety of plant heights by autumn, with some covering of flowering grasses and wildflowers left to go to seed and tussocky grass allowed to develop

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Grazing management	Updated CS (SP8)	92£ or 146£ per ha dependent on grazing livestock units	Grazing is increased with vary rates of rare breeds of livestock which are included in the native breed support list and categorised as either vulnerable, endangered or critical on sensitive grazing habitats
	Updated CS (SP8)	7£ or 11£ per ha dependent on grazing livestock units	Grazing is increased with vary rates of rare breeds of livestock which are included in the native breed support list and categorised as either vulnerable, endangered or critical on sensitive grazing habitats
	Existing CS (GS17)	28£ per ha	Throughout the growing season, grassland is lightly grazed with cattle, or both cattle and sheep, so there is a range of shorter and taller grasses
Green manure	Existing SFI (NUM2)	102£ per ha	There are legumes growing from spring until early autumn
Agroforestry	Sustainable Farming Incentive (SFI)	248£/ha	Maintain very low density in-field agroforestry on less sensitive land
	Countryside Stewardship (CS)	248£	Maintain very low density in-field agroforestry on more sensitive land
		385£	Maintain low density in-field agroforestry on less sensitive land
		385£	Maintain low density in-field agroforestry on more sensitive land
		595£	Maintain medium density in-field agroforestry
		849£/ha	Maintain high density in-field agroforestry
Nutrient management plan	Existing SFI (NUM1)	652£ per agreement (agreement level action, limited to one 'live' agreement)	You assess your current approach to nutrient usage, and effectively plan how to manage nutrient usage more efficiently and effectively, and plan how to optimise use of organic sources of crop nutrition
	Existing SFI (NUM2)	102£ per ha	There are legumes growing from spring until early autumn

Strategies	Source of financial support	Payment mechanism	Specific conditions for participation
Nutrient management plan	Existing SFI (SAM1)	6.00£ per hectare (ha) plus 97£ per agreement	You understand the condition of your soil and effectively plan how to increase its long-term health, productivity and resilience
	Existing CS (SW7)	489£ per ha	There is a dense, diverse grass sward throughout the year, with low fertiliser inputs
	Existing SFI (NUM3)	593£ per ha	There is a legume fallow that produces areas of flowering plants from late spring and during the summer months
Precision fertilisation	new	27£ per ha	Precision farming variable rate technology is used to apply nutrients on arable, horticultural land or improved permanent grassland, to match the nutrient needs of crops for different areas within land parcels
	Existing SFI (SAM1)	6.00£ per hectare (ha) plus 97£ per agreement	You understand the condition of your soil and effectively plan how to increase its long-term health, productivity and resilience
Regenerative agriculture	N/A	N/A	N/A

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Supplementary information materials

Austria

National legislation

The Austrian funding system is based on the European CAP (common agricultural policy). Information on all types of funding in Austria (ÖPUL, direct support scheme, compensatory supplement, LEADER, young farmer funding, and basic payment for alpine pastures and the coupled alpine grazing premium) can be found at:

https://info.bml.gv.at/themen/landwirtschaft/gemeinsame-agrarpolitik-foerderungen.html

Austria's programme for the promotion of an agricultural management system is the Agri-environmental Programme (ÖPUL).

https://www.fao.org/faolex/results/details/en/c/LEX-FAOC192244/

Subsidies and grants

The national legislation in in accordance with the legislation of the European Union:

https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en#legal-foundations

The detailed legally valid provisions of ÖPUL 2023 are regulated in the special national directive ÖPUL 2023 of the Federal Minister of Agriculture, Forestry, Regions and Water Management (BML) for the Austrian programme to promote environmentally friendly, extensive agriculture that protects the natural habitat. The basis for the special directive ÖPUL 2023 is the CAP Strategic Plan Austria 2023 to 2027, which was approved by the European Commission.

https://info.bml.gv.at/dam/jcr:d2051318-e7ad-4f9f-b5d0-1a4c173be001/SRL_OEPUL_2023.pdf

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Bulgaria

National legislation

Law for the Protection of Agricultural Lands

https://www.mzh.government.bg/media/filer_public/2018/10/08/zakon_za_opazvane_na_zemedelskite_zemi.pdf

Law on the ownership and use of agricultural lands

https://lex.bg/laws/ldoc/2132550145

Law for soils

https://lex.bg/laws/ldoc/2135569762

Handbook for practical application of the conditions for the maintenance of the land in good agricultural and ecological condition in Bulgaria

https://www.moew.government.bg/static/media/ups/tiny/%D0%A3%D0%9E%D0%9E%D0%9F/%D0%9F%D0%9E%D0%A7%D0%92%D0%98/%D0%9D%D0%90%D0%A6%D0%98%D0%9E%D0%9D%D0%90%D0%9B%D0%9D%D0%90%20%D0%9F%D0%A0%D0%9E%D0%93%D0%A0%D0%90%D0%9C%D0%90.pdf

The National Program for Conservation, Sustainable Use and Restoration of Soil Functions

https://agri.bg/documents/narchnik-za-praktichesko-prilozhenie-na-usloviyata-za-poddrzhane-na-zemyata-v-dobro-zemedelsko-i-ekologichno-sstoyanie-v-blgariya

Subsidies and grants

Information about possible financial support in Bulgaria (Bulgarian Paying Agency, State Fund Agriculture) can be found here:

https://www.dfz.bg/bg/home

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Czech Republic

National legislation

Act No. 334/1992 Coll. Act of the Czech National Council on the Protection of the Agricultural Land Fund
https://www.zakonyprolidi.cz/cs/1992-334

Law for Spatial Planning
https://www.zakonyprolidi.cz/cs/1998-197

Law No. 289/1995 Coll. Law on Forests and on Amendments to Certain Acts (Forest Law)
https://www.zakonyprolidi.cz/cs/1995-289

Law for the Land Consolidation Plans
https://www.zakonyprolidi.cz/cs/2002-139

Act No. 254/2001 Coll. Water Act and on Amendments to Certain Acts (Water Act)
https://www.zakonyprolidi.cz/cs/2022-382

Subsidies and grants

Information about possible financial support in Czech Republic can be found here:

The Ministry of Agriculture of the Czech Republic
http://eagri.cz/public/web/mze/dotace

Operational Programme Environment
http://www.opzp.cz

The State Environmental Fund of the Czech Republic
http://www.sfzp.cz

Nature Conservation Agency of the Czech Republic
https://www.nature.cz/web/cz/dotacni-nastroje

The State Agricultural Intervention Fund
https://www.szif.cz/en/szif_provides

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China

China's Agricultural Direct Subsidy Policy

2004年 中央一号文件，中共中央国务院关于促进农民增收若干政策的意见 中发2004 1号
https://www.gov.cn/gongbao/content/2004/content_63144.htm

2004年，中国全面推广农业直接补贴政策，包括粮食直接补贴政策、良种补贴、农机购置补贴、农业生产资料综合补贴，

China's Food Security Strategic Guidance Document

2008年，政府发布《国家粮食安全中长期规划（2008-2020）》，成为中国粮食安全的最新战略性指导文件。

A programmatic document for the green development of China's agriculture.

2017年中共中央办公厅、国务院办公厅发布《关于创新体质机制推进农业绿色发展的意见》，https://www.gov.cn/zhengce/2017-09/30/content_5228960.htm

中国农业政策的发展，转变为关注资源约束和环境污染治理，农业在提质增效过程中朝着可持续方向发展。

Soil Pollution and Soil Protection

2016.5，国务院印发《土壤污染防治行动计划》（简称"土十条"），
"土十条": 到2030年我国实现土壤环境风险全面管控.
https://www.gov.cn/xinwen/2016-06/01/content_5078562.htm

Ecological Protection

《中共中央、国务院关于灾后重建、整治江湖、兴修水利的若干意见》(中发[1998]15号)
天然林保护工程（1998）
1998年发生在长江流域和东北地区的两次特大洪灾，至今仍让许多人记忆犹新。正是那年大水，让人们尝到了生态破坏的恶果。洪水退去后，中共中央、国务院提出全面停止长江、黄河流域上中游的天然林采伐。

Returning Farmland to Forest Project

《国务院关于进一步做好退耕还林还草试点工作的若干意见》（国发[2000]24号）
https://www.gov.cn/gongbao/content/2000/content_60486.htm

《国务院关于进一步完善退耕还林政策措施的若干意见》（国发[2002]10号）
https://www.gov.cn/gongbao/content/2002/content_61463.htm

和《退耕还林条例》（国务院令第367号）的规定，
https://www.gov.cn/gongbao/content/2003/content_62531.htm

长期以来，由于盲目毁林开垦和进行陡坡地、沙化地耕种， 造成了我国严重的水土流失和风沙危害，洪涝、干旱、沙尘暴等自然灾害频频发生，人民群众的生产、生活受到严重影响，国家的生态安全受到严重威胁。
1999年，四川、陕西、甘肃3省率先开展了退耕还林试点，由此揭开了我国退耕还林的序幕。2002年1月10日，国务院西部开发办公室召开退耕还林工作电视电话会议，确定全面启动退耕还林工程。

Ecological benefit compensation

《中华人民共和国森林法》

https://www.gov.cn/xinwen/2019-12/28/content_5464831.htm

1984年9月20日第六届全国人民代表大会常务委员会第七次会议通过 根据1998年4月29日第九届全国人民代表大会常务委员会第二次会议《关于修改〈中华人民共和国森林法〉的决定》第一次修正 根据2009年8月27日第十一届全国人民代表大会常务委员会第十次会议《关于修改部分法律的决定》第二次修正 2019年12月28日第十三届全国人民代表大会常务委员会第十五次会议修订。

为了践行绿水青山就是金山银山理念，保护、培育和合理利用森林资源，加快国土绿化，保障森林生态安全，建设生态文明，实现人与自然和谐共生，制定本法。

第七条，国家建立森林生态效益补偿制度，加大公益林保护支持力度，完善重点生态功能区转移支付政策，指导受益地区和森林生态保护地区人民政府通过协商等方式进行生态效益补偿。

Regulations on Ecological Protection Compensation

（国令第779号）2024年6月1日起施行。

https://www.gov.cn/gongbao/2024/issue_11306/202404/content_6947725.html

全面贯彻落实习近平生态文明思想，坚持绿水青山就是金山银山的理念，将党中央、国务院关于生态保护补偿的规定和要求以及行之有效的经验做法，以综合性、基础性行政法规形式予以巩固和拓展，确立了生态保护补偿基本制度规则，以充分发挥法治固根本、稳预期、利长远的作用。

生态保护补偿，是指通过财政纵向补偿、地区间横向补偿、市场机制补偿等机制，对按照规定或者约定开展生态保护的单位和个人予以补偿的激励性制度安排。生态保护补偿可以采取资金补偿、对口协作、产业转移、人才培训、共建园区、购买生态产品和服务等多种补偿方式。

Land Reclamation Regulations

国务院令第592号 2011.3.5
https://www.gov.cn/flfg/2011-03/11/content_1822635.htm

本条例所称土地复垦，是指对生产建设活动和自然灾害损毁的土地，采取整治措施，使其达到可供利用状态的活动。

为了落实十分珍惜、合理利用土地和切实保护耕地的基本国策，规范土地复垦活动，加强土地复垦管理，提高土地利用的社会效益、经济效益和生态效益

Land Administration Law of the People's Republic of China,

1986.6.25，第六届全国人民代表大会常务委员会第十六次会议通过. 1987年1月1日期实施. 根据2019年8月26日第十三届全国人民代表大会常务委员会第十二次会议《关于修改〈中华人民共和国土地管理法〉、〈中华人民共和国城市房地产管理法〉的决定》第三次修正
http://www.npc.gov.cn/npc/c2/c30834/201909/t20190905_300663.html

特殊保护耕地、严格控制建设用地”和“优化市场配置、构建城乡统一建设用地市场”并重的管理制度，在提高土地利用质量和效益上取得新进展

Grades of Cultivated Land Quality

（GB/T 33469-2016）国家标准，经国家质检总局、国际标准委员会，于2016.12.30起正式实施。
https://www.gov.cn/xinwen/2017-01/06/content_5157047.htm

中国首部耕地质量等级国家标准，填补了中国国家层面耕地质量评价缺少统一标准的空白，具有系统性、专门性和可操作性的特点，为耕地质量调查监测与评价工作的开展，提供了科学的指标和方法，对在新形势下提高中国耕地质量管理与保护水平具有里程碑式的意义.

Measures for the Management of Agricultural Soil Environment

（试行），2017.9.25环境保护部、农业部令第46号公布，自2017.11.1起施行
https://www.gov.cn/zhengce/2017-09/25/content_5711506.htm

为了加强农用地土壤环境保护监督管理，保护农用地土壤环境，管控农用地土壤环境风险，保障农产品质量安全

Soil Pollution Prevention and Control Law of the People’s Republic of China

2018年8月31日第十三届全国人民代表大会常务委员会第五次会议通过
https://www.gov.cn/xinwen/2018-08/31/content_5318231.htm

为了保护和改善生态环境，防治土壤污染，保障公众健康，推动土壤资源永续利用，推进生态文明建设，促进经济社会可持续发展，制定本法

Black Soil Protection Law of the People’s Republic of China

2022.6.24通过，2022.8.1起施行。中华人民共和国第十三届全人民代表大会常务委员会第35次会议通过.
http://www.npc.gov.cn/npc/c2/c30834/202206/t20220624_318288.html

为了保护黑土地资源，稳步恢复提升黑土地基础地力，促进资源可持续利用，维护生态平衡，保障国家粮食安全，制定的法律

Yellow River Protection Law of the People’s Republic of China

2022.10.30通过， 2023.4.1起施行。中华人民共和国第十三届全人民代表大会常务委员会第37次会议通过.
http://www.npc.gov.cn/npc/c2/c30834/202210/t20221030_320097.html

为了加强黄河流域生态环境保护，保障黄河安澜，推进水资源节约集约利用，推动高质量发展，保护传承弘扬黄河文化，实现人与自然和谐共生、中华民族永续发展，制定的法律

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Hungary

National legislation

The Hungarian funding system is based on the European CAP (common agricultural policy). Information on all types of funding in Hungary can be found at:

https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_hu

Detailed rules for receiving support under the Agro-ecological Programme (AÖP) in Hungary.
https://net.jogtar.hu/jogszabaly?docid=a2300015.am

Law on the protection of agricultural land
https://net.jogtar.hu/jogszabaly?docid=a0700129.tv

Subsidies and grants

The European Union's new Common Agricultural Policy (CAP) for the period 2023-2027 will make agriculture fairer, greener and more results-oriented. In addition to its previous objectives, the reformed CAP from 2023 onwards will focus on providing more targeted support for smaller farms and increasing sectoral contribution to the EU's environmental and climate objectives, while giving Member States the opportunity and greater flexibility to adapt measures to local conditions. Hungarian CAP subsidies and grants:

https://www.nak.hu/kap-2023-2027
https://www.nak.hu/kiadvanyok/kiadvanyok/7038-agro-okologiai-program-2023/file

The AÖP 2023 in Hungary is supervised by the Ministry of Agriculture supporting environmental-friendly agriculture. The basis of the AÖP 2023 is the CAP Strategic Plan Hungary 2023-2027, which was approved by the European Commission.

In Hungary, the basic expectation for all farmers using AÖP support is the Farming Keeping and electronic submission of a Farmers' Diary. Detailed requirements and options:

https://www.nak.hu/images/2022/AOP_valaszthato_gyakorlatok_kovetelmenyek.pdf

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Italy

National legislation

The Italian funding system is based on the European CAP (common agricultural policy). The national ministry for agriculture has provided a document containing guidelines for regional programmes, called PSP, Piano Strategico Nazionale della PAC (National Strategic Plan for CAP). An outline of the objectives and measures of the PSP document can be found at:

https://www.reterurale.it/PSPexplorer

Then, every Region or autonomous province (21 in Italy) can produce a more specific document, called CSR, Complemento regionale per lo sviluppo rurale del PSP 2023-2027 (Reginal complement for rural development), that is, in practice, the operative tool of the national strategy. This document, that sets which practices will be promoted, which limitations to farm types or other constraints, the agenda of the various calls, and the amount of the subsidy provided can be found at each region/autonomous province institutional website.

Subsidies and grants

All information on subsidies and grants are region-specific. The web pages are:

Abruzzo
https://www.regione.abruzzo.it/avvisi/pac-2023-2027

Basilicata
https://basilicatacsr.it/

Calabria
https://www.calabriapsr.it/pac-2023-2027/la-pac-2023-2027

Campania
http://www.agricoltura.regione.campania.it/CSR_2023-2027/CSR-23-27.html

Emilia Romagna
https://agricoltura.regione.emilia-romagna.it/sviluppo-rurale-23-27

Friuli Venezia Giulia
https://europa.regione.fvg.it/it/programmi-36605/ps-pac-23-27-39986

Lazio
https://www.lazioeuropa.it/csr-feasr/

Liguria
https://www.agriligurianet.it/it/impresa/sostegno-economico/programma-di-sviluppo-rurale-psr-liguria/csr-2023-2027.html

Lombardia
https://psr.regione.lombardia.it/it/pc2127/psr-2023-2027

Marche
https://www.regione.marche.it/Regione-Utile/Agricoltura-Sviluppo-Rurale-e-Pesca/Sviluppo-Rurale-2023-2027/CSR-Marche-23-27

Molise
https://psr.regione.molise.it/programma2327

PA Bolzano
https://agricoltura.provincia.bz.it/it/piano-strategico-nazionale-2023-2027

PA Trento
http://www.psr.provincia.tn.it/Sviluppo-Rurale-2014-2020/PAC-2023-2027

Piemonte:
https://www.regione.piemonte.it/web/temi/fondi-progetti-europei/sviluppo-rurale-piemonte/complemento-regionale-per-sviluppo-rurale-2023-2027-csr

Puglia
https://www.regione.puglia.it/web/agricoltura/piano-strategico

Sardegna
https://sardegnapsr.it/csr/che-cos-e-il-csr/

Sicilia
https://www.psrsicilia.it/notizie/psp-2023-2027-piano-strategico-della-pac/

Toscana
https://www.regione.toscana.it/sviluppo-rurale-2023-2027

Umbria
https://www.regione.umbria.it/csrumbria

Valle d'Aosta
https://www.regione.vda.it/agricoltura/CSR_2023_2027/default_i.aspx

Veneto
https://venetorurale.it/sviluppo-rurale-veneto-2023-2027/

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Spain

National legislation

The Spanish Agrarian Guarantee Fund (FEGA, in Spanish) is an autonomous institution under the Ministry of Agriculture, Fisheries and Food. Its primary mission is to ensure that the funds from the European Agricultural Guarantee Fund and the European Agricultural Fund for Rural Development, which are part of the Common Agricultural Policy (CAP) allocated to Spain, are rigorously applied to meet the objectives of this policy. This ensures that the funds effectively reach beneficiaries who comply with the established requirements.

More information related to the specific conditions of participation in sources of financial support can be found on the website of FEGA at https://www.fega.gob.es/es.

For more detailed and specific information on financing, the following links can be visited:

- Conditionality and common requirements:
- https://www.fega.gob.es/es/pepac-2023-2027/condicionalidad-requisitos-comunes
- Direct payment:
- https://www.fega.gob.es/es/pepac-2023-2027/ayudas-directas
- Rural Development 2023-2027:
- https://www.fega.gob.es/es/pepac-2023-2027/desarrollo-rural-2023-2027
- Sectoral interventions:
- https://www.fega.gob.es/es/pepac-2023-2027/intervenciones-sectoriales

Regarding soil health the following national regulations and related links are worthy to be mentioned:

- Forestry Law (Ley 43/2003, de 21 de noviembre, de Montes): https://www.boe.es/eli/es/l/2003/11/21/43/con
- National strategy to combat desertification: https://www.miteco.gob.es/content/dam/miteco/es/biodiversidad/temas/desertificacion-restauracion/estrategia_nacional_lucha_desertificacion_web_2022_tcm30-542085.pdf
- Legislation on fertiliser products (Real Decreto 506/2013, de 28 de junio, sobre productos fertilizantes): https://www.boe.es/eli/es/rd/2013/06/28/506/con
- Law on waste and contaminated soils (Ley 7/2022, de 8 de abril, de residuos y suelos contaminados para una economía circular): https://www.boe.es/eli/es/l/2022/04/08/7/con
- Vulnerable areas to nitrate pollution (Real Decreto 47/2022, de 18 de enero, sobre protección de las aguas contra la contaminación difusa producida por los nitratos procedentes de fuentes agrarias): https://www.boe.es/eli/es/rd/2022/01/18/47/con
- National Soil Erosion Inventory: https://www.miteco.gob.es/es/biodiversidad/servicios/banco-datos-naturaleza/informacion-disponible/inventario_nacional_erosion.html
- Subsidies and grants

Source of financial support:

Non inversion till:

- CAP, Enhanced Conditionality GAEC 5: Minimal tillage management, reducing the risk of soil degradation and erosion, including taking into account slope inclination.

No-till:

- CAP, Eco-scheme P4: Direct sowing on dry farmland (Iberian Peninsula).
- CAP, Eco-scheme P4: Direct sowing on humid dry farmland (Balearic Islands).
- CAP, Eco-scheme P4: Direct sowing on irrigated farmland (Iberian Peninsula).
- CAP, Eco-scheme P4: Direct sowing on dry farmland (Balearic Islands).
- CAP, Eco-scheme P4: Direct sowing on irrigated farmland (Balearic Islands).
- CAP, Enhanced Conditionality GAEC 9: Prohibition of converting or ploughing permanent grasslands declared as environmentally sensitive permanent pastures in Natura 2000 areas.

Cover crops:

- CAP, Eco-scheme P6: Vegetative covers in woody crops on flat terrain (slope less than 5%; Iberian Peninsula).
- CAP, Eco-scheme P6: Vegetative covers in woody crops on medium slope terrain (slope equal to or greater than 5% and less than 10%; Iberian Peninsula).
- CAP, Eco-scheme P6: Vegetative covers in woody crops on steep terrain and terraces (slope equal to or greater than 10%; Iberian Peninsula).
- CAP, Eco-scheme P6: Vegetative cover in woody crops on flat terrain (slope less than 5%; Balearic Islands).
- CAP, Eco-scheme P6: Vegetative covers in woody crops on medium slope terrain (slope equal to or greater than 5% and less than 10%; Balearic Islands).
- CAP, Eco-scheme P6: Vegetative covers in woody crops on steep terrain and terraces (slope equal to or greater than 10%; Balearic Islands).
- CAP, Enhanced Conditionality GAEC 6: Minimum soil cover to prevent bare soils during the most sensitive periods.

Crop residue incorporation:

- CAP, Eco-scheme P7: Inert covers in woody crops on flat terrain (slope less than 5%; Iberian Peninsula).
- CAP, Eco-scheme P7: Inert covers in woody crops on medium slope terrain (slope equal to or greater than 5% and less than 10%; Iberian Peninsula).
- CAP, Eco-scheme P7: Inert covers in woody crops on steep terrain and terraces (slope equal to or greater than 10%; Iberian Peninsula).
- CAP, Eco-scheme P7: Inert covers in woody crops on flat terrain (slope less than 5%; Balearic Islands).
- CAP, Eco-scheme P7: Inert covers in woody crops on medium slope terrain (slope equal to or greater than 5% and less than 10%; Balearic Islands).
- CAP, Eco-scheme P7: Inert covers in woody crops on steep terrain and terraces (slope equal to or greater than 10%; Balearic Islands).

Crop rotation:

- CAP, Eco-scheme P3: Crop rotation with improving species on dry farmland (Iberian Peninsula).
- CAP, Eco-scheme P3: Crop rotation with improving species on humid dry farmland.
- CAP, Eco-scheme P3: Crop rotation with improving species on irrigated farmland (Iberian Peninsula).
- CAP, Eco-scheme P3: Crop rotation with improving species on dry farmland (Balearic Islands).
- CAP, Eco-scheme P3: Crop rotation with improving species on irrigated farmland (Balearic Islands).
- CAP, Enhanced Conditionality GAEC 7: Crop rotation on arable land except for crops under water.

Vegetated buffer strips:

- CAP, Enhanced Conditionality GAEC 4: Creation of buffer strips along river margins.

Hedges:

- CAP, Eco-scheme P5: Biodiversity spaces in farmland and permanent crops.
- CAP, Enhanced Conditionality GAEC 8.1: Minimum percentage of agricultural area to be dedicated to non-productive features or areas.
- CAP, Enhanced Conditionality GAEC 8.2: Maintenance of landscape features.
- CAP, Enhanced Conditionality GAEC 8.3: Prohibition of cutting hedges and trees during the bird breeding and nesting season.

Reduction of grazing intensity and grazing management:

- CAP, Eco-scheme P1: Extensive grazing on the surfaces of wet pastures.
- CAP, Eco-scheme P1: Extensive grazing on the surfaces of Mediterranean pastures.
- CAP, Eco-scheme P1: Extensive grazing on the surfaces of Mediterranean island pasture surfaces.

Agroforestry:

- CAP, Enhanced Conditionality GAEC 1: Maintenance of permanent grassland based on a ratio of permanent pasture to the agricultural area at a regional scale compared to the reference year 2018.

Precision fertilisation:

- CAP, Enhanced Conditionality GAEC 10: Sustainable fertilization.

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United Kingdom

National legislation

Agriculture Act 2020
Agriculture Act 2020 (legislation.gov.uk)
Agricultural Land (Removal of Surface Soil) Act 1953
Agricultural Land (Removal of Surface Soil) Act 1953 (legislation.gov.uk)
Soil related policies in the UK (October 2022)
Devolved_soil_related_policies_2023.pdf (sustainablesoils.org)

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International

https://www.youtube.com/watch?v=bLO0lc7IRJo

https://www.isqaper-is.eu/sqapp-the-soil-quality-app/amps-in-sqapp

https://qcat.wocat.net/en/wocat/

https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health/soil-health-management

https://www.extension.purdue.edu/extmedia/AY/AY-363-W.pdf

https://www.nrcs.usda.gov/resources/guides-and-instructions/conservation-practice-standards

https://www.nrcs.usda.gov/resources/guides-and-instructions/filter-strip-ac-393-conservation-practice-standard

https://www.edenriverstrust.org.uk/wp-content/uploads/2018/12/11882_NFM_handbook_WEB.pdf

BACK TO SOIL DEGRADATION PROCESS SELECTION

Conclusions

Presented material originated with support of experts for various fields of soil conservation from countries participating in TUdi project.

Main aim was to put together various strategies how to prevent and mitigate soil deterioration. Control measures and strategies were selected from those, which are practically used in individual countries and potential state support and also effectiveness, including synergy effects for various soil damages were also taken into account.

There are also links to state and EU supporting, subsidies and motivating programs for farmers within individual countries included. Same information as for EU territory has been provided also by Chinese experts, what is enriching information value of material for new approaches, measures and strategies.

All measures, strategies and information are closely linked to Decision Support Tools (DSTs), which were developed within TUdi project as mobile and also online desktop apps, to help farmers to identify evidence and potential extent of soil damages and to suggest optimum control measures and mitigation strategies.

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