

EU4GREEN

MEASURES FOR SUSTAINABLE
WATER USE IN AGRICULTURE
ON THE FIELD



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Sustainable Water Usage in Agriculture.

SUSTAINABLE WATER CONSERVATION STRATEGIES FOR AGRICULTURE

This brochure is designed to encourage farmers to adopt sustainable water use practices and storage measures. It also serves as a resource for agricultural advisors working with small-scale farms to help them become more resilient in the face of water shortages and droughts caused by climate change.

The brochure presents a range of measures designed to reduce water consumption, retain water in fields and soil, and improve the efficiency of water use and irrigation systems.

Climate Change in Agriculture in the Western Balkans

Like the rest of Europe, the Western Balkans are increasingly affected by climate change. The most serious consequences are rising temperatures, changing weather patterns and irregular precipitation patterns. Extreme weather events such as prolonged drought, heavy rainfall and flooding are becoming more frequent.

Farmers are often particularly affected by droughts and water shortages. Climate change will lead to a regional and seasonal decrease in water availability, while higher temperatures and the associated evaporation as well as a longer vegetation period will increase the demand for water for crop production. Combined with unevenly distributed precipitation, the probability of dry periods and heat stress for plants and animals increases significantly. In the future, periods of drought with significant yield reductions and feed quality losses for livestock could occur more frequently, last longer and be more severe in large parts of the Western Balkans and the rest of Europe.

The Importance of Protecting Water Resources

Water for irrigation and livestock is becoming increasingly scarce, forcing farmers to adapt to ensure long-term resilience. One possible solution is improving rainwater retention within the land and region in which it falls.

Water resources are essential for ensuring food security, stable crop yields and economic success in farming. Future meteorological and hydrological shifts demand improved management strategies. Climate change is expected to reduce regional water availability while simultaneously increasing the need for irrigation due to higher temperatures and extended growing seasons.

Protecting water resources is vital. Intensive land management can weaken natural water retention, making fields more vulnerable to droughts, heavy rainfall and erosion. In contrast, sustainable practices enhance resilience and reduce flood risks while optimizing water availability.

Key strategies to support water conservation and regional agriculture include:

- Increase water absorption and infiltration for efficient rainfall use
- Optimize existing water reserves to maximize moisture retention
- Minimize evaporation losses to retain water where it is needed most

A combined approach—reducing water demand while improving water retention within fields—will help farmers safeguarding their productivity and mitigate water scarcity.

The implementation of on-farm measures to enhance water storage helps to:

- Increase resilience to declining and seasonally fluctuating water availability
- Safeguard economic stability by minimizing crop losses
- Enhance profitability through improved resource efficiency

Water Storage Methods

1. Soil Moisture Storage

Soil moisture storage refers to the water held in the soil within the plant's root zone. Measures to enhance soil moisture storage usually involve reducing or preventing water runoff, employing structures that capture water and encourage its absorption into the soil (e.g. agroforestry systems, greening runoff paths). Other measures such as catch crops, cover crops and mulching improve the soil's water storage capacity by increasing its humus content - an organic material capable of retaining up to five times its weight in water. These techniques enhance the soil's ability to absorb rainfall by ensuring that moisture is available for plants.

2. Groundwater Storage

Groundwater storage refers to water that infiltrates beyond the root zones of crops, eventually percolating into aquifers where it is stored as groundwater. Various measures such as agroforestry can be employed to collect surface runoff and facilitate its infiltration, effectively increasing groundwater reserves.

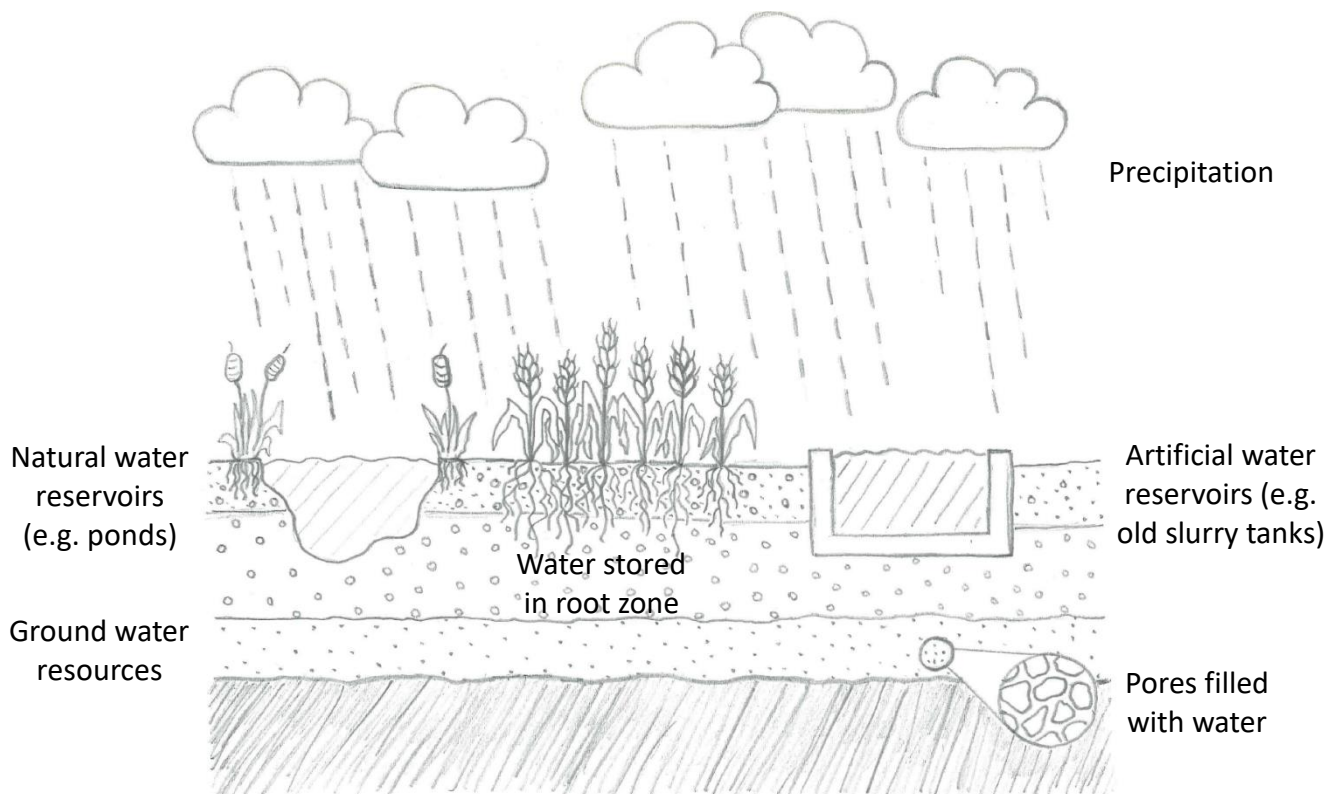
3. Surface Water Storage

Surface water can be stored in natural or artificial ponds or tanks for later use in irrigation. These storage systems can be filled by harvesting water from various sources:

- Rainwater harvesting involves collecting runoff from roofs or ground surfaces (overland flow)
- Floodwater harvesting captures water from streams and rivers when the water level rises above average (i.e. channel flow)

These measures enable farmers to store water when it is abundant and use it during dry periods when crops need it most. The harvested water can be stored in:

- Water retention ponds distributed over a river catchment area: Multiple small ponds effectively store water for irrigation
- Existing structures such as abandoned manure and slurry pits



Water storage. © Manuela Bürgler

AGROFORESTRY

Agroforestry is a farming approach that integrates trees and shrubs into agricultural systems to create a more sustainable and productive environment. Traditionally, farmers cultivate only one or a few species in a field for reasons of efficiency but integrating woody plants with agricultural can provide a wide range of benefits. Grassland and pastures as well as horticulture or vineyards can also benefit from the presence of trees or bushes among the main cultivars.

Agroforestry systems are described as agrosilvicultural, silvipastoral or agrosilvipastoral systems, depending on whether forestry is combined with arable or grassland cultivation and/or animal browsing. There are many ways in which trees and bushes can be combined with agriculture:

- Shelterbelts
- Tree rows or alleys
- Hedges, with or without larger trees
- Dispersed single trees or bushes



Agroforestry. © Manuela Bürgler

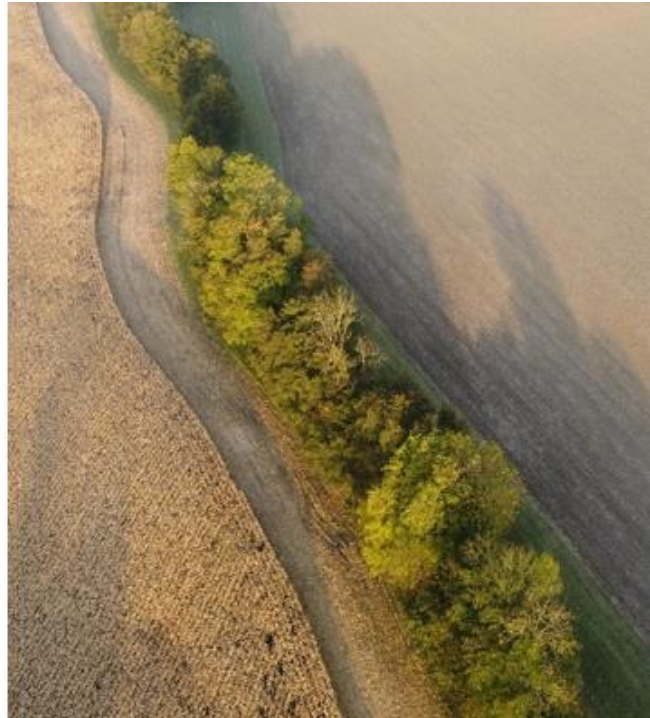
Key Benefits

Trees offer a range of different direct uses and functions, reflecting the diversity of agroforestry systems. Ideally, these uses emerge in combination or mixture:

- Healthy dietary elements for humans and animals (source of e.g. fruits, nuts)
- Litter bedding in the stable
- Energy wood
- Timber
- Special products such as cork, coloring pigments or crafting materials
- Fencing structures and physical landmarks, border marking



Scattered fruit trees. © Mevlida Dudo Suvakic



Strips of woody plants next to arable land. © Gebhard Banko



Trees and Hedges. © Mevlida Dudo Suvakic

Improvement of the microclimate and stabilizing soil moisture by trees and hedges:

- Shading improves water absorption, reduces water loss and evapotranspiration
- Protection of crops from excessive irradiation
- Cooling effects, reduced evaporation and heating
- Increased dew formation due to reduced wind speed
- Soil protection from erosion and wind
- Reducing water runoff, increasing infiltration and contribution to ground water storage

Improving soil quality:

- Trees and woody vegetation can stabilize steeper slopes and reduce the risk of landslides and erosion, especially along track and path escarpments
- Providing organic material for the formation of humus and supporting soil microorganisms through foliage as well as improving root penetration

Biodiversity, climate change mitigation and other benefits:

- Increasing biodiversity: Creating ecological niches for birds, insects, microorganisms and other organisms
- Supporting beneficial organisms, natural pest control and reducing the risk of infections
- Binding carbon, filtering pollutants, retaining water in the root zone, and utilizing nutrients from deeper soil layers

Implementation Considerations

- Select tree species that compete minimally with arable crops for water, nutrients and light
- Young trees require care: remove excessive undergrowth and ensure timely weed control
- Production benefits (fruit, timber) may take years or decades to materialize, requiring long-term planning

Benefits for Farmers and Key Takeaways

Agroforestry systems can improve soil health and water availability, increase crop diversity and productivity and bolster resilience against extreme weather.

- Having a variety of crops provides diversified income possibilities (fruits, nuts etc.)
- Eventually also access to payments for environmental services

Knowledge need



Farm resilience



Water conservation



Agroforestry. © Ramona Cech

GREENING RUNOFF PATHS ON FIELDS

Soil erosion damages the soil structure and reduces its water storage capacity. Surface water often runs off in concentrated streams through hollows and depressions (preferred runoff paths), causing gully erosion. These areas should be protected with permanent vegetation. Permanent vegetation protects the soil, the surface is rougher, and the transportation of soil particles becomes more difficult, causing the sediment to settle, preventing further erosion

Key Benefits

- Reduces soil erosion
- Maintains soil structure and its capacity to store water
- Reduces nutrient runoff into waterbodies (water pollution)
- Keeps soil material from uphill areas within fields
- Prevents loss of nutrients and reduction of organic matter content in soil

Implementation Considerations

Where and how should greened runoff paths be established?

- Identify preferred runoff paths, usually located where surface water flows off the depth line with visible erosion (gullies) Sow perennial cover crops after the main crop harvest to ensure establishment before winter
- If annual plants (e.g. sunflowers, marigolds) are mixed in, cultivation should take place in spring



A furrow between the greened runoff path and the surrounding farmland should be avoided. A flowing transition is recommended to better divert the runoff water into the vegetation. © Manuela Bürgler



Possibilities for greening runoff paths on fields: Visible runoff path on the field (top left), greening along a runoff path (top right), generous greening that covers part of the runoff path (lower left), generous greening that covers the entire area of the runoff path (lower right). © Manuela Bürgler

Possibilities for Greening Runoff Paths on Fields

- Converting visible runoff path into permanent grassland
- Temporary or partial revegetation
- Undersowing in area of runoff paths
- Weed management: Weeds are left in the runoff path area to provide the necessary vegetation
- Greening only parts of visible runoff paths or the entire area of the runoff path

Benefits for Farmers and Key Takeaways

- Greening runoff paths can prevent damage to crops
- Enables more effective use of farm resources such as seeds, fertilizer and pesticides

Knowledge need 

Farm resilience 

Water conservation 

CATCH AND COVER CROPS

Catch and cover crops are planted during fallow periods, i.e. between harvesting one crop and sowing the next. They use residual soil moisture and are terminated either before or shortly after the next crop is sown, but always before the crops begin to compete for resources.

The main purpose of catch crops is to "catch" excess nutrients (such as nitrogen) that might otherwise leach out of the soil during fallow periods. This reduces nutrient loss to groundwater.

Cover crops are mainly grown to protect and improve the soil.



Cover crops © Barbara Färber-Hallama

Key Benefits

- Prevention of erosion, enhancement of soil structure
- Protection against soil crusting, prevention of soil damage
- Suppression of weeds
- Nitrogen conservation and land regeneration: Preserves soil nutrients, restores degraded soils by adding organic material, increases organic matter content, retains arable land
- Improving resilience to heat and drought: Conserve soil moisture by limiting the evaporation, allowing soils to store water for a longer period
- Enhancing water management: Some crop roots break through dense soil layers, improving water absorption
- Increasing adaptability to heavy rainfall

Implementation Considerations

To ensure successful implementation, farmers should be aware of certain challenges:

- Select Catch and cover crops based on soil type, climate and cropping system
- Prefer Drought-tolerant species
- Ensure Cover crops complement, not interfere, the main crop

Benefits for Farmers and Key Takeaways

- The use of catch and cover crops reduces the need for fertilizers, herbicides and irrigation, which can lower costs
- Cover crops can also be used as livestock feed, although they are not grown for commercial purposes

Knowledge need



Farm resilience



Water conservation



A field of leguminous cover crops. © Barbara Färber-Hallama

CROP ROTATION

Crop rotation is an agricultural technique which refers to cultivating different types of plants in a temporal sequence on the same (plot of) land. Growing the same crops year after year can deplete the soil, leading to a significant loss of nutrients and organic matter.

Key Benefits

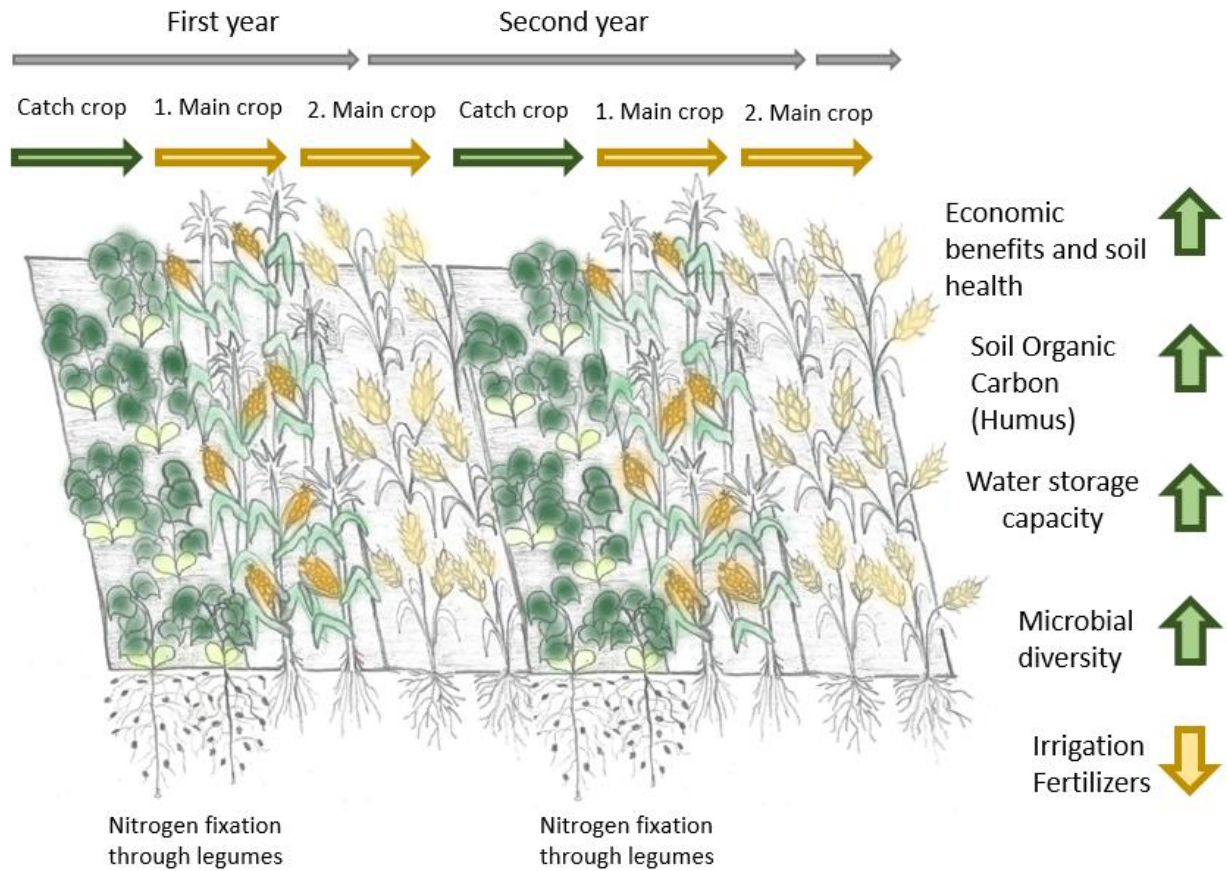
The integration of permanent grassland, forage crops or grain legumes in the crop rotation enhances the resilience of cropping systems under hot and dry conditions. Crop rotation can help regulate the water cycle in landscapes by balancing moisture retention and reducing runoff. This approach conserves soil moisture and improves plant access to water resources by:

- Facilitating better distribution of water and nutrients throughout the soil profile
- Promoting greater distribution of channels or biopores created by diverse roots (varied forms, sizes and depths)
- Enabling the roots of multiple plant species to explore different soil strata for nutrients and water, thereby maximizing resource utilization

Implementation Considerations

Rotating crop species each season or agricultural cycle is an effective way of preventing soil depletion.

- Flexibly adjust the sequence to regional conditions, soil type and climate
- When planning crop rotations, avoid growing crops from the same plant family in succession and alternate heavy feeders with medium or light feeders and nitrogen-fixing crops (legumes) to prevent nutrient depletion
- Use legumes such as lentils, chickpeas or beans as catch crops after a main crop such as maize or sunflowers. This can be followed by grains such as wheat, barley or oats
- The transition from a mono-cropping system to diversified crop rotation can take time and experimentation



© Manuela Bürgler

Example for crop rotation: nitrogen fixing catch crops with first main crop (e.g. grain maize) and an overwintering second main crop (e.g. winter cereals)

Benefits for Farmers and Key Takeaways

Crop rotation is a powerful tool that can help any farmer to improve productivity and long-term fertility of their land:

- Crop rotation with legumes enhances nitrogen fixation and leads to greater humus formation
- With legumes, it can reduce the dependence on Nitrogen-fertilizers. The nitrogen fixation capacity of previous legume crops can increase the amount of nitrogen in the soil by 36% to 49%
- It provides higher microbial abundance and diversity, which supports soil health and fertility
- It improves agrobiodiversity at farm and landscape-levels over space and time, increasing habitat niches for wildlife biodiversity
- It improves plant health and reduces pest and disease pressure by interrupting life cycles of pests and pathogens

Measures for Sustainable Water Use in Agriculture on the Field

- Diversified crop rotation enhances sustainability and weather resilience by lowering the risk of crop failure, contributing to stable yields
- Crop rotation increases plant diversity, which leads to higher financial returns and reduces the risk of significant financial losses due to pest and weed infestations
- Diversified systems outperform monocultures by enhancing individual crop yields and ensuring stable yields over time

Knowledge need



Farm resilience



Water conservation



Illustration of crop rotation.

MULCHING

Mulching involves covering the soil between crop rows or around trees or vegetables with cut grass, crop residues, straw or other plant material.

Key Benefits:

Mulch is applied to soil to create a protective layer and to manage the microclimate.

- Improving resilience to heat and drought: Conserves soil moisture by limiting evaporation and allows the soil to store water for longer periods
- Improving water infiltration: Enhances the soil's ability to absorb water and increases the amount of usable water
- Enhancing soil health: Improves soil structure, soil life and increases soil fertility
- Preventing soil erosion: Protects against degradation and maintains soil integrity



Mulched field. © Barbara Färber-Hallama

Implementation Considerations

Mulch can be used in both agriculture and horticulture. Mulching is an easy way to retain soil moisture, but it is important to choose the right type.

- Organic mulches such as straw, leaves and compost work well, but the wrong choice of mulch can lead to excess moisture or nitrogen depletion
- Apply a balanced depth (5–10 cm), this helps to prevent pests and weeds
- Use properly sourced mulch or compost materials to avoid contamination
- Consider that in hot climates, light mulch can be of advantage, as it reflects heat, while darker mulch retains warmth and is therefore recommended in colder regions

Benefits for Farmers and Key Takeaways

- Possible positive impacts of enhanced soil quality and water availability on yields
- Weed prevention: Suppresses the growth of unwanted plants and reduces costs of weed control measures

Knowledge need



Farm resilience



Water conservation



Mulching process.

VARIETY SELECTION

Due to the impact of climate change, crop yields may vary depending on factors such as altitude, temperature, water availability and irrigation. Variety selection offers an opportunity to adapt to changing abiotic conditions.

Examples of climate-resilient crops suitable for Mediterranean climates include:

- Quinoa
- Camelina
- Sweet potato
- Tritordeum (a hybrid crop derived from crossing durum wheat with wild barley)



© Manuela Bürgler

Key Benefits

Adapting to climate change and securing farm income and resilience are key objectives of crop diversification.

- Quinoa: Highly adaptable to harsh growing conditions, requires minimal water and nutrients. Thrives in various soil types, diverse pH ranges and in both organic and conventional systems. Suitable for high altitudes, even above 2000 meters
- Camelina: Exceptionally adaptable to diverse soil and pH conditions. Performs well under both organic and conventional systems. Features a short biological cycle of approximately 70 days and can be grown as either a summer or winter crop, making it ideal for Mediterranean climates
- Sweet Potato: Remarkably versatile, adapting to a variety of soil types, pH levels. Suitable for high altitudes, even above 2000 meters
- Tritordeum: Resistant to challenging climates, with low demands for water and nutrients

Implementation Considerations

- Select crops with traits tailored to regional condition and regional impacts of climate change
- Prefer crop varieties with a high tolerance to drought and heat
- Prefer crops with deep roots

Benefits for farmers and Key Takeaways

Farmers are encouraged to adapt to climate change by diversifying their farming systems.

- Climate-resilient crops secure income, minimize water and nitrogen losses and reduce costs for the use of chemical inputs
- Alternative crops can help to mitigate the negative effects of rising temperatures and water scarcity, thereby ensuring farm profitability

Knowledge need



Farm resilience



Water conservation



Quinoa field.



Sweet Potato.

ORGANIC FERTILIZATION

The main methods of organic fertilization are to spread manure and apply compost, although alternatives (e.g. sewage sludge) exist. The effectiveness of organic fertilizers on soil and yield depends on the type, quantity, quality, timing and method of application.

Benefits for Farmers and Key Takeaways

Applying organic fertilizers such as compost, manure or slurry to agricultural soil provides nutrients and helps to:

- Build up and maintain humus
- Boost soil fertility and microbial activity
- Increase plant growth and crop yields and thus income
- Improve the soil structure
- Increase the ability to retain water in the soil



Manure

Applying livestock manure is an effective way to fertilize agricultural soils, providing nutrients for the crops and increasing yields. Manure contains high concentrations of easily degradable organic material that can be rapidly converted by soil microorganisms. Through this process, nutrients become available to crops. However, the effectiveness of farmyard manure as a fertilizer depends on various factors including climatic conditions, the type and amount of fertilizer used, as well as the soil type. It is also important that organic fertilizers are applied (timing, application method) and stored correctly to minimize nutrient losses.

There are three main types of manure, which differ in consistency and therefore require different application methods:

Liquid Manure:

- Liquid component of excrements from livestock (urine)

- Easily soluble (plants can access the contained nutrients quickly)
- Usually spread using a slurry tank with a baffle plate that distributes the manure evenly over the surface by rotating

Solid Manure:

- Solid component of excrement from livestock (manure)
- Often mixed with bedding material (straw)
- Usually stored in manure heaps and distributed either manually or by a manure spreader on fields or grassland

Slurry:

- Mixture of solid and liquid components of excrements from livestock (manure)
- Sometimes diluted with water (ratio 1:1) for easier spreading
- Usually spread with a slurry tank with a rotating baffle plate
- Spreading slurry close to the ground (for example, using several hoses extending directly from the slurry tank to the ground to dispense the slurry there) greatly reduces the loss of nitrogen into the air

Implementation Considerations (Manure on Cropland)

- Incorporate the slurry into the soil of unvegetated areas within a few hours, as the loss of nutrients into the air is highest immediately after spreading
- Do not apply slurry and liquid manure on frozen, snow-covered or water-saturated soil
- Do not apply outside the growing season (winter)
- Keep sufficient distance from water bodies (e.g. rivers, streams, lakes) to prevent nutrients from entering the water
- Do not apply on steeply sloping ground, which can lead to surface runoff

PREVENT NUTRIENT LOSSES FROM MANURE DURING STORAGE

Collect slurry in leak-proof slurry pits and cover them to prevent loss of nitrogen through emissions into the air.

Store manure heaps on a well-sealed surface. Cover the manure heap with a plastic sheet or a roof to minimize nutrient losses through rainwater seepage.

Implementation Considerations (Manure on Grassland)

- In spring, solid manure can be applied, as soon as the ground is passable again (due to lower temperatures) to reduce spreading losses and forage contamination
- Liquid manure is well absorbed by plants in spring and should be applied between the greening of the sward and the start of plant growth
- Cattle slurry can be used on forage meadows from early spring to fall
- Use slurry or liquid manure for grass-rich crops (80% grasses), which require a higher proportion of easily soluble nitrogen for growth

In General: Abstain from the use of heavy machinery for application of organic fertilizers when the ground is saturated with water due to strong precipitation, to prevent soil compaction.



Manure heap on a sealed concrete surface with walls on three sides to prevent seepage of nutrients into the soil. Seepage is drained and collected via a channel grid. © Bettina Schwarzl

Compost

Compost is another form of organic fertilizer, primarily made from plant matter. Through the targeted reuse of plant material, the soil can be supplied with nutrients when livestock manure is unavailable or provides a valuable addition to it. However, this plant material must first be processed to make its nutrients available to crops. Unlike slurry, for example, the nutrients in compost necessary for plant growth are slowly released into the soil over a longer period of time.

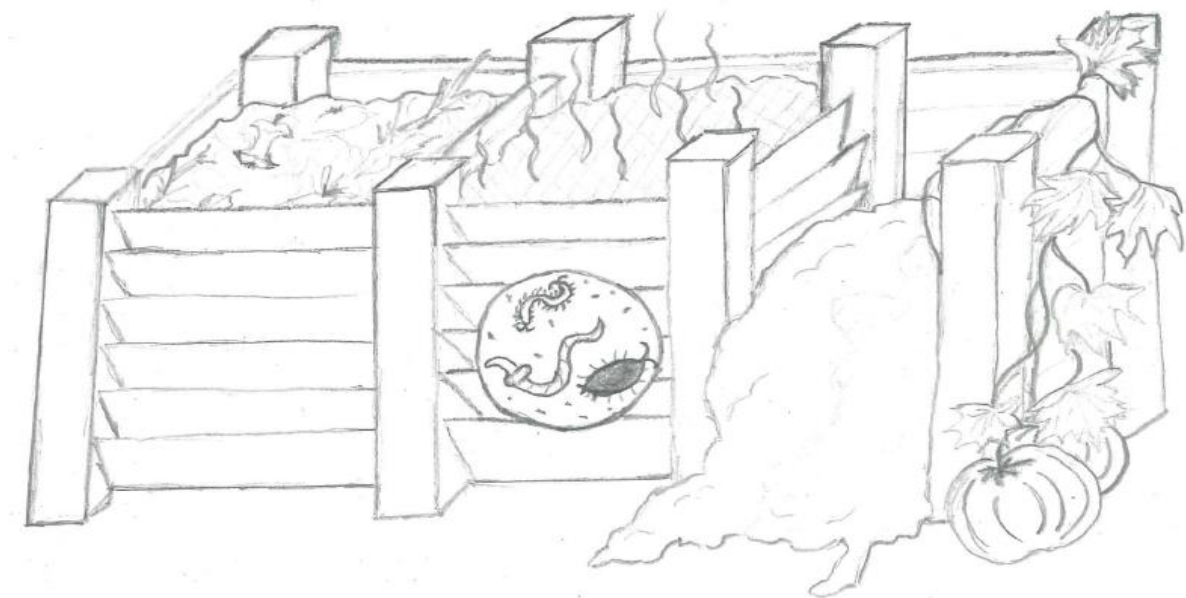
Implementation Considerations (Compost Production)

Compost can be produced either in a compost rack (made of wooden slats and regular openings, for example) or in a traditional compost heap.

- Direct contact with open soil is important so that microorganisms and other soil organisms can migrate into the compost from below. These organisms ensure that organic waste is decomposed
- Ideally, nitrogen-rich materials such as grass and organic waste should be alternated with carbon-rich materials such as leaves and shredded tree cuttings
- The compost heap should be kept moist and well aerated, which requires regular turning
- If the compost becomes too dry, it is recommended to moisten it with water
- The rotting process can be accelerated by covering it with a plastic sheet

Starting materials for composts

- Biogenic waste from markets, households, gardens and agriculture (e.g. grass, leaves, tree and shrub cuttings, fruit and vegetable waste, crop residues)
- Livestock manure



Valuable fertilizer can be obtained by composting bio-waste and green waste. © Manuela Bürgler

EFFICIENT IRRIGATION

The brochure focuses on the sustainable use of water for small-scale irrigation, in which each farm is responsible for irrigating its own plot. Approximately 60% of irrigated farms in the Western Balkan region rely on groundwater as their primary water source, while 40% use surface water.

Individual irrigation is simple to implement and economically viable, making it a preferred method for cultivating high-value crops that can easily offset irrigation costs. To promote sustainable water use, existing irrigation structures should be designed to enhance efficiency and integrate improved water management into farming practices.

Key Benefits

- Conservation of local and regional water resources (available for other uses and wildlife)
- Contributing to sustainable water use and reducing water scarcity

Implementation Considerations

Reduce water demand

Efficient irrigation management is based on a multi-factor approach, first focusing on reducing water demand and then on using water efficiently.

The water demand can be reduced by making forward-looking decisions:

- Select site-adapted and climate resilient crops: In general, crop types and varieties should be selected that can cope with the local conditions. To ensure the best possible yields, it is necessary to select crops that are drought-tolerant or able to adapt to limited water availability
- Increase soil health to improve its water infiltration capacity, water storage capacity and avoidance of soil compaction

Do not overwater

- Use demand-oriented irrigation instead of fixed irrigation schedules: Use soil moisture sensors and/or models to estimate the current amount of water required by the plants
- Use deficit irrigation: the amount of irrigation water applied is less than the crop's actual water requirement to increase the yield per unit of water applied and, consequently, the economic return.

Select the best available and most efficient irrigation technique according to crop and economic requirements

Depending on the type of crop, different irrigation technologies are suitable:

- Furrow irrigation should be replaced by sprinklers to improve water use efficiency for crops, which cannot be irrigated by drip irrigation.
- Wherever possible, use highly efficient techniques like drip irrigation, micro sprinkler irrigation and subsurface irrigation

Selection of irrigation timing/scheduling

- No irrigation in the midday heat
- No sprinkling at high wind speeds to improve the efficiency

Improvement of irrigation infrastructure - reduce water losses in distribution and piping systems

- Lined canals reduce water losses compared to earthen canals
- Wherever possible, choose closed pipes as they outperform lined canals in terms of water losses
- Introduce routines for checking and repairing the water distribution system
- Prevent illegal water withdrawals
- Clarify the use of treated wastewater, where (legally) possible

Benefits for Farmers and Key Takeaways

Efficient water use helps to secure the local agricultural businesses in the long term. The main short-term benefits are:

- Reduction of water costs
- Reduction of costs for manpower
- Reduction of non-productive water use
- Increase in the economic viability of the farm

USER GUIDE

Assessment of Measures

The following box gives a quick overview of the most important properties of measures. The number of icons (1-3) next to it indicates the extent of the respective property:

- Knowledge: The more light bulb icons shown in the box, the more knowledge is required to implement the measure
- Farm resilience: The more farm building icons there are in the box, the more the measure will contribute to securing the long-term existence of the farm. This includes maintaining soil health and stable yields, financial stability and long-term resource availability in general
- Water conservation: The more water drop icons are shown in the box, the greater the water storage potential of this measure

Knowledge need			
Farm resilience			
Water conservation			



Irrigation System.

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