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CARBON 4 SOIL QUALITY

Carbon farming techniques: key for maintaining soil organic carbon

Benefits, drawbacks and mitigation potential...

Final conference: "**Carbon Farming: Benefits in the Mediterranean region"**

Thessaloniki, Greece| 10 December 2025

Institution| Department: Institute of Agriculture, Ss Cyril and Methodius University

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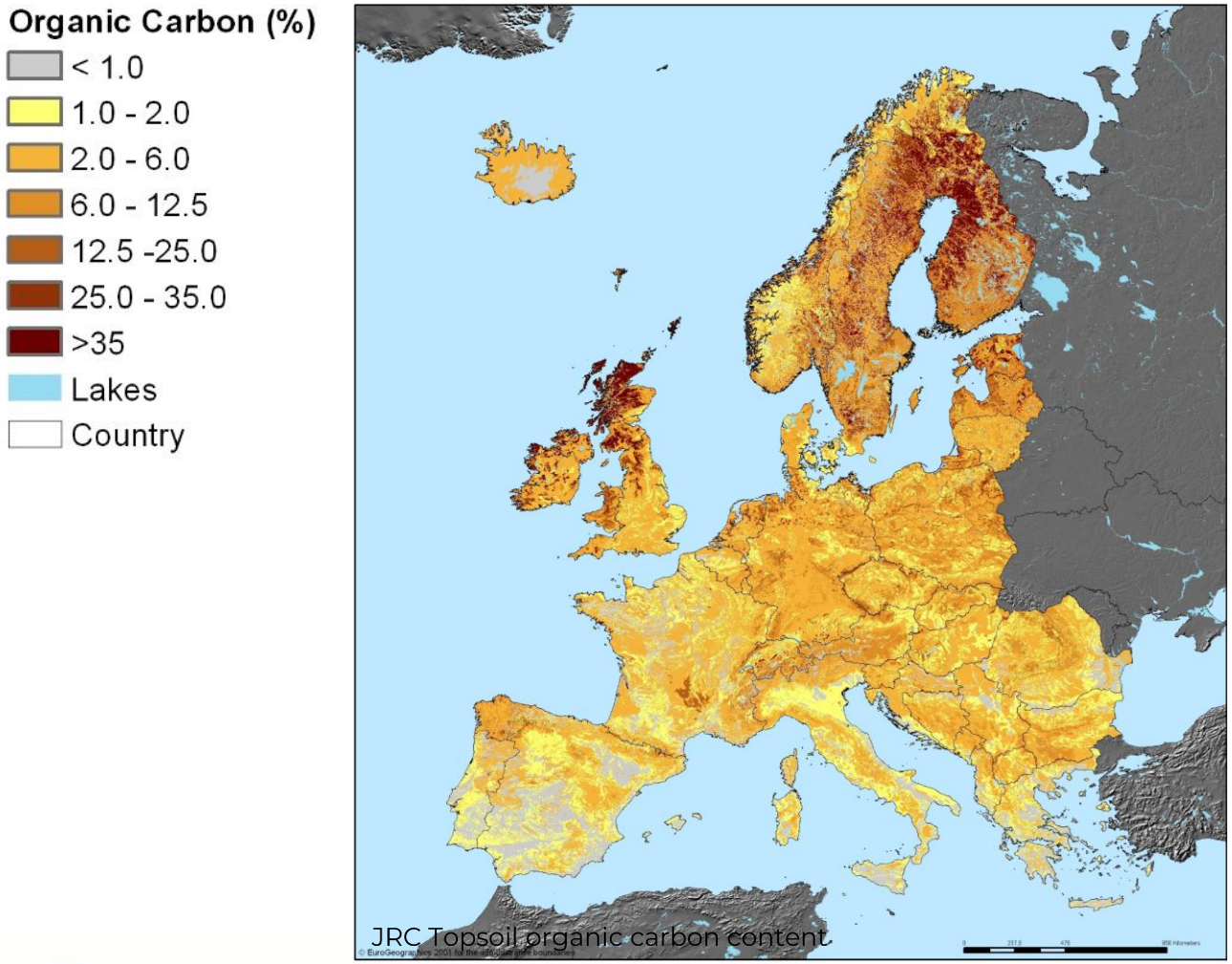
SOC contents in Mediterranean soils



JRC Topsoil organic carbon content

In a case current agricultural systems remain unchanged Southern and Eastern Europe are projected to experiencing a decline in soil carbon stocks by 2100 due to climate change,

Big areas within Mediterranean zone in Spain, Italy, Greece contains less than 1% organic carbon,

In such circumstances maintaining of current SOC stock would be a significant achievement,

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Carbon farming as a concept

Why SOC is so important?

➢**SOC - primary indicator of soil health and fertility.**

Central role in virtually every physical, chemical, and biological process

➢Carbon farming - **integrated land management approach**

Combines a set of **sustainable agricultural practices** that

- enhance soil organic matter,
- reduce greenhouse-gas emissions, and
- promote healthier, more resilient ecosystems.

Objectives of the study

- Main objective of the Study is ***to identify and study Best Management Practices*** (BMPs) aimed at increasing soil organic matter content in Euro-Mediterranean countries.
- Seventeen (17) BMPs were identified and classified in the four categories:
  - Soil management techniques
  - Organic additions
  - Cultivation practices
  - Cultivation systems

Objectives and methodology

- Soil management
  - Organic mulch
  - Conservation tillage
  - No-tillage
  - Strip Tillage, Precision tillage, Zone tillage

- Organic additions
  - Manure
  - Crop residue incorporation
  - Compost,
  - Biochar,
  - Sewage sludge
  - Digestate

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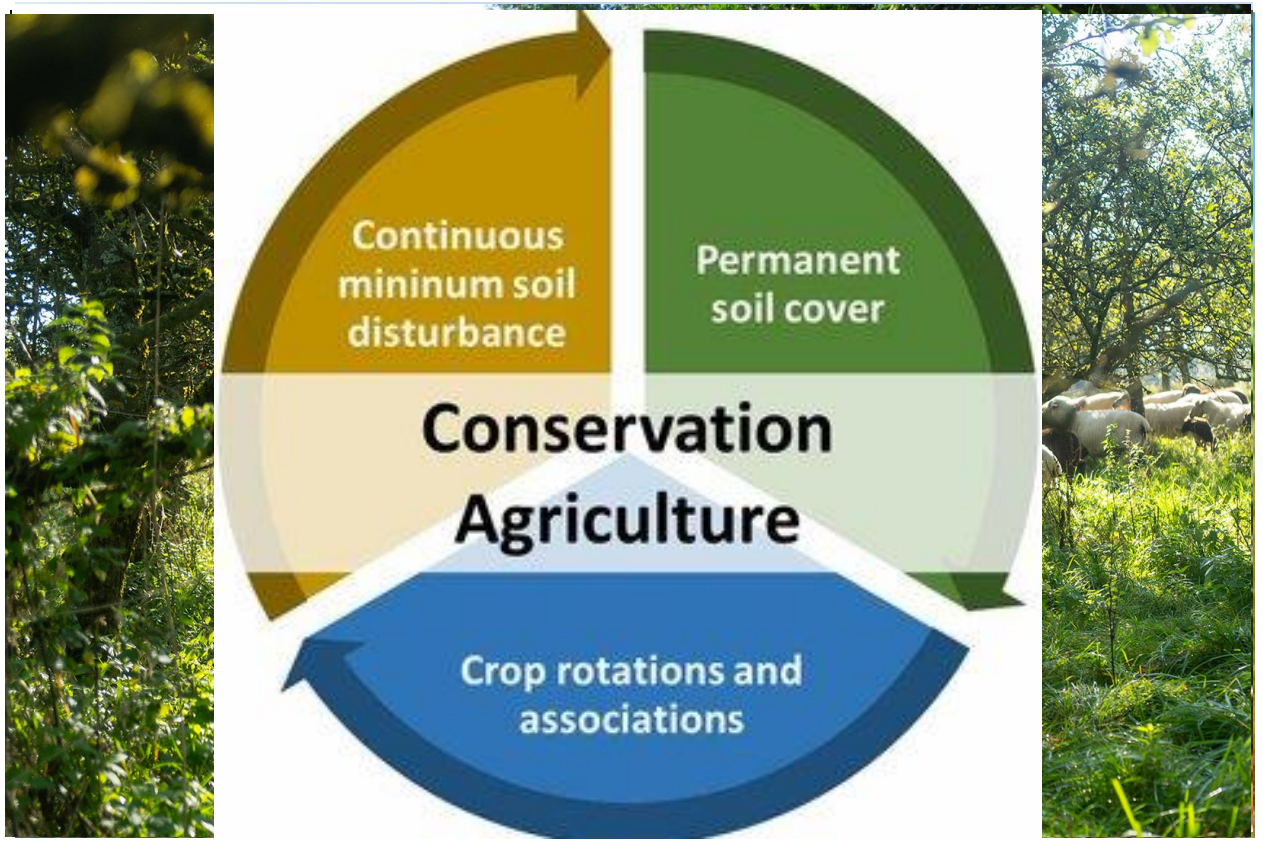
Objectives and methodology

- Cultivation practices
  - Crop rotations
  - Increasing root biomass
  - Conversion to grassland
  - Cover cropping
  - Intercropping

- Cultivation systems
  - Agroforestry
  - Organic farming
  - Conservation agriculture



Objectives and methodology

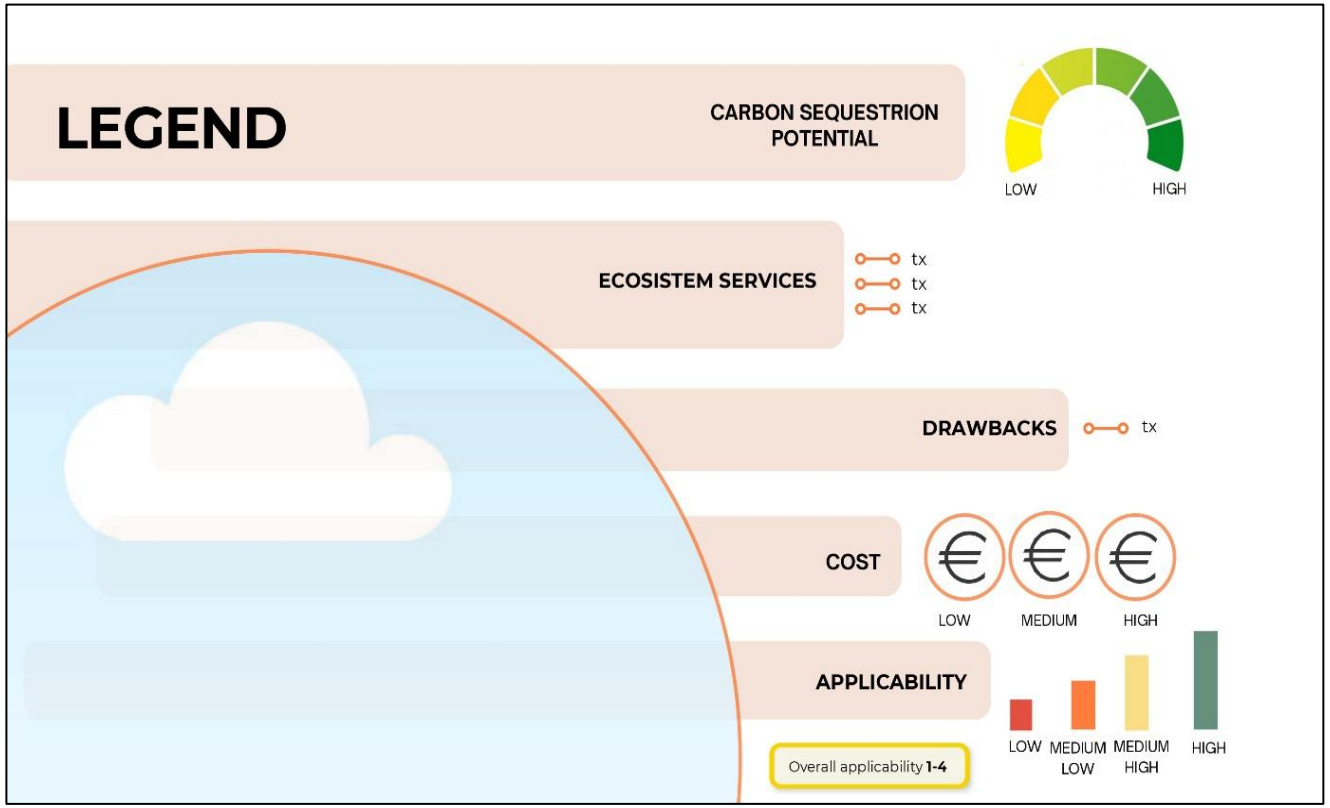
The BMPs were evaluated against 5 criteria:

- **Mitigation potential** – the extent to which a given BMP enhances carbon removal (carbon sequestration) from the atmosphere and increases soil organic carbon (SOC) stocks, expressed either in t/ha or as a percentage.
- **Associated benefits** – the additional positive effects, beyond the accumulation of organic matter, that the implementation of a specific measure has on soil properties, soil functions, and overall soil quality.
- **Disadvantages** – the limitations, risks, or potential adverse consequences that may arise from applying a specific measure, particularly if it is implemented incorrectly.
- **Costs** – the expenditure required for the application of a given measure, including costs related to mechanization, transport, additional labor, and material inputs.
- **Geographical applicability** – the extent to which natural conditions (such as climate and soil type) or administrative constraints influence the feasibility of implementing a specific measure.

Objectives and methodology

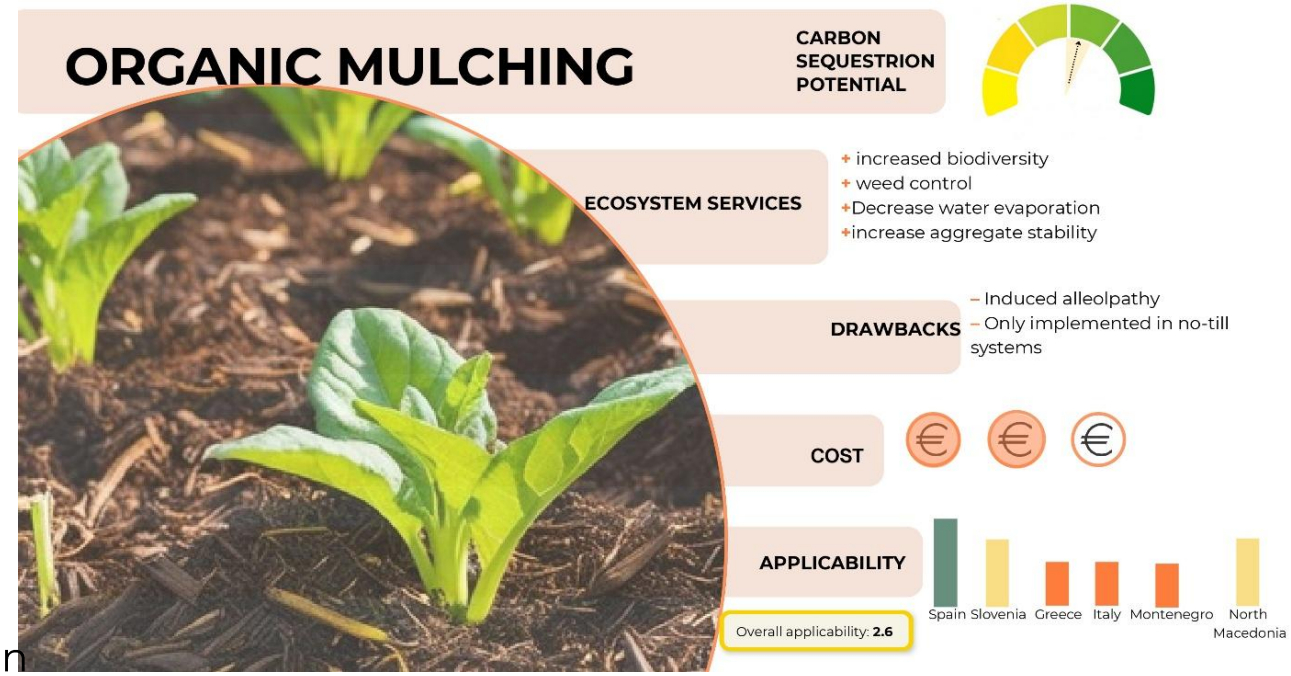
The identification and evaluation of the BMPs were carried out based on:

- An in-depth literature review of more than 50 reference sources
- Existing data and information from the partner countries in the Project
- The collected information for all evaluation criteria is visually presented in the form of infographics



Soil management techniques

- **Organic mulching:** Any biodegradable material applied to the soil to prevent erosion and water loss
  - ➢ **Mitigation Potential**: depends on the type of agriculture practiced over time and the specific pedoclimatic characteristics of the soil.
  - ➢ **Co-benefits**: effective technique for:
    - weed control,
    - balancing of SOC quantities ,
    - regulation of the microclimate,
    - enhances soil water retention,
    - improves water use efficiency and
    - enhances soil structure,
  - ➢ **Disadvantages:** some mulches with low C:N decompose rapidly and provide extra N to the soil MO which increases production of nitrous oxide (N2O).
  - ➢ **Geographical suitability**: Mulching can be applied in any pedoclimatic region



Organic additions

- **Manure:** organic matter originating from animal's excreta, such as faeces and urine, containing plant material (straw) which is used for animal bedding

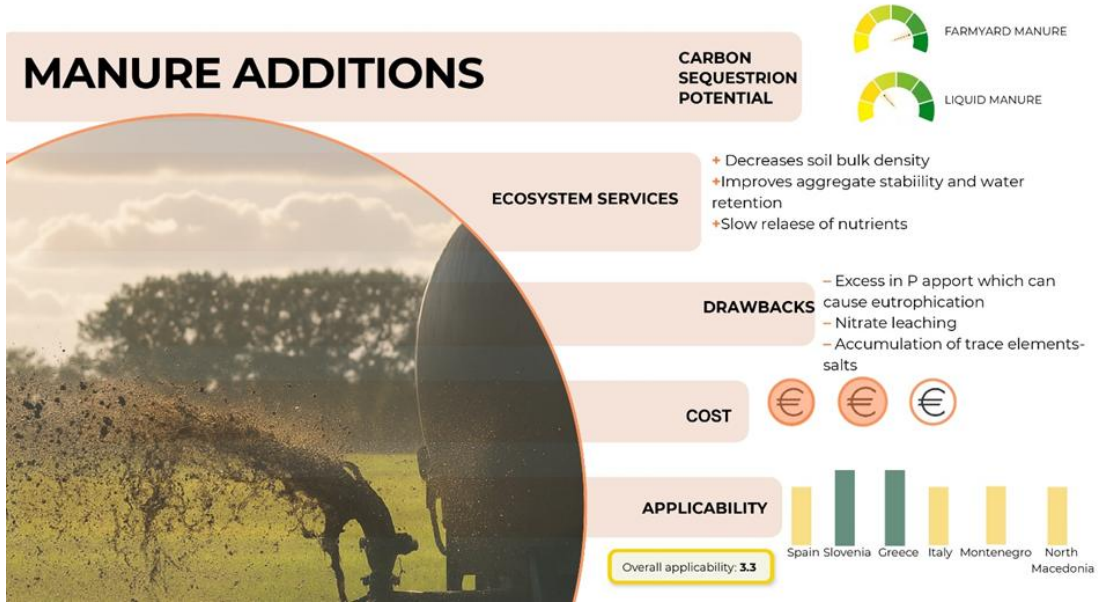
  - **Mitigation Potential**: depends to
    - manure type, doses, time of application and
    - parallel agricultural practices.
    - increase of **46% in SOC stock in upper 30 cm** of soil in Mediterranean area

  - **Associated Benefits**:
    - decreases soil bulk density,
    - improves aggregate stability and
    - enhances soil water retention

  - **Disadvantages:**
    - nitrate leaching may occur
    - if not properly fermented - proliferation of weeds,
    - drying of the topsoil

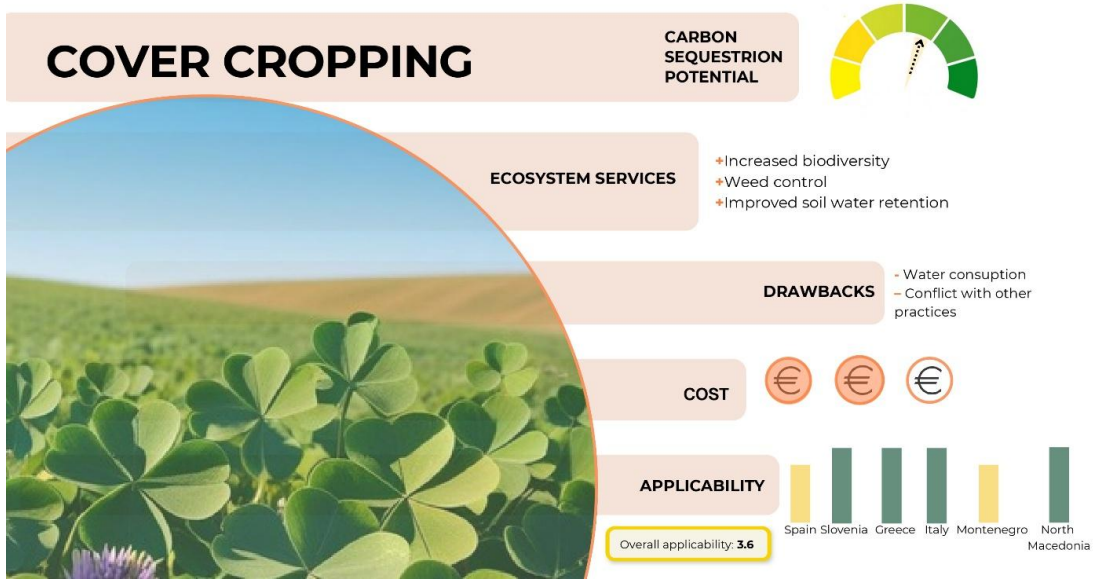
  - **Geographical suitability:** No restrictions for application in the Mediterranean area,

  - **Costs:** The application of large quantities of manure involves high transport and labor costs.



Cultivation practices

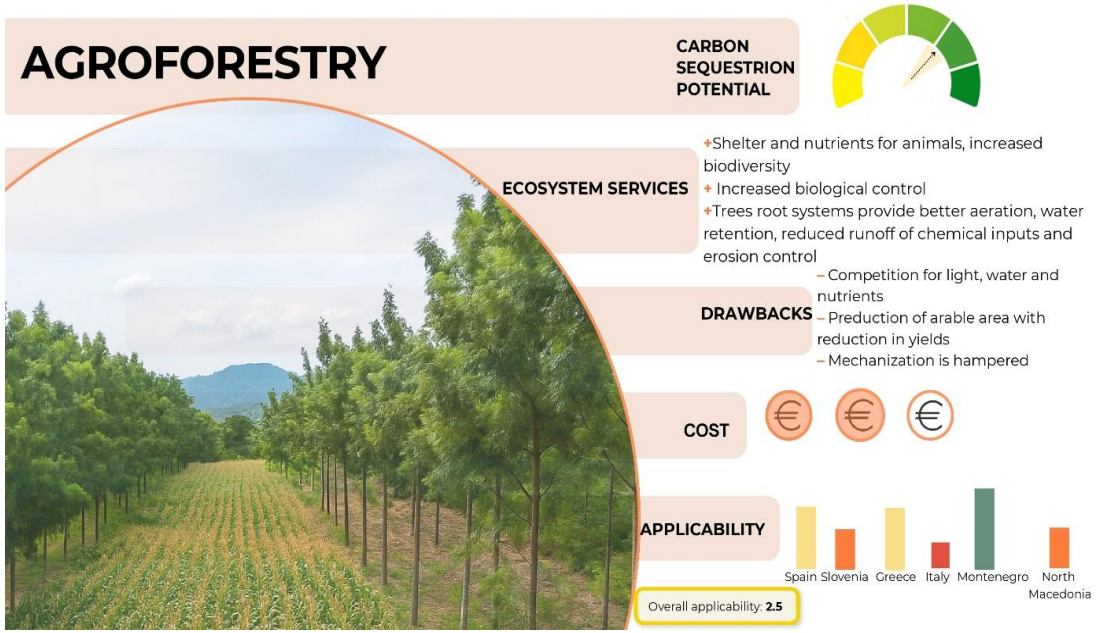
- **Cover cropping**: Any plant species that is grown between two periods of normal crop production, or between trees in orchards and vineyards
  - **Mitigation potential:** additional ***C storage of 1.03 tC/ha/year, and 45% increase of SOC after 9-10 years***, in the Mediterranean basin
  - **Associated benefits:**
    - protecting the soil from erosion,
    - enhance biodiversity,
    - act as suppressants of weeds and control pests and diseases.
  - **Disadvantages:** excessive water use by the cover crops - could have negative an impact to the following cash crop.
  - **Geographical suitability:** possible competition of cover crops for available soil water in some semi-arid regions, of the Mediterranean basin,
  - **Costs:** two main costs: fuel and labor (range from **18 €/ha to 58 €/ha,** depending on management practices)



Cultivation systems

Agroforestry: type of agricultural system that integrates the cultivation of perennial trees and/or shrubs with arable land and/or pasture within the same area.

- **Mit. Pot.:** if worldwide 10% arable land were covered with trees, approximately $18x10^9$ tons of carbon could be sequestered
- **Add. ben.:** The mix of trees and hedgerows with cash crops on arable land provides:
  - shelter and nutrients for animals,
  - increases biodiversity and
  - promotes biological control of pests
- **Disadvantages**
  - more specific mechanization,
  - reduction in arable area and
  - the decreased light penetration - yield reductions of cereal in Italy—**up to 42%.**
- **Geo. Suit.:** Several examples in the Mediterranean area;
  - "Viti maritate" (i.e., grape vines on living trellis) in Italy,
  - "Dehesa" (i.e., agrosylvopastoral systems) in Spain and
  - Mix between cereals and olive groves in Greece.



Conclusions

- A wide range of measures is available, and when properly implemented, they can have a strong positive impact on soil organic carbon (SOC) accumulation and overall soil quality.
- All measures carry equal importance, and therefore prioritization among them is not possible.
- Each measure brings additional benefits but also certain potential risks that must be carefully considered during implementation.
- The application of the proposed BMPs requires additional costs and labor, which introduces a degree of uncertainty and risk for farmers.
- In many countries, farmers often have limited adaptive capacity; therefore, the proposed measures must be easy to implement, affordable, and supported with appropriate incentives.
- It is crucial that these measures are actively promoted among farmers through demonstration fields, living labs, training programs, and similar knowledge-transfer activities.

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Thank you for your attention

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