

# TRAINING MATERIAL

## MODULE 2

### **FARMING BETTER: SOIL, CLIMATE, AND PLANTS – EXPLORING THEIR INTERCONNECTIONS AND REGENERATIVE PRACTICES**



## TITLE

BalkansGrow Training Material - Module 2: "Farming Better: Soil, Climate, and Plants – Exploring their interconnections and regenerative practices"

## ERASMUS+ BALKANSGROW PROJECT COORDINATION

Univerza v Mariboru

## DOCUMENT EDITING AND COORDINATION

Associació Cultural CRESOL

## AUTHORS

Isis Torales (Associació Cultural CRESOL)

José Segarra (Associació Cultural CRESOL)

Imane Ouadi (Associació Cultural CRESOL)

## REVISION

Marina Tosheska; Gjorgjija Gagaleski(LAG AGRO LIDER)

Ivan Marković; Milica Jaramaz (CSO, Centre for Vocational Education)

Polona Šprajc (FOV, UM)

Zorana Markovic; Petar Knežević (CRNVO)

Enida Bogdani; Julia Çekrezi (KUTIA)

Erina Disho; Ana Mino ("Mihal Shahini" VET School)

## EDITION DATE

June 2026

## FINANCING

European Education and Culture Executive Agency (EACEA), Erasmus+ Programme, European Union.

|                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                 |
|------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Project                                                                                                                | Green Resilient Organic Wisdom                                                                                                                                                                                                                                                                                                                                                  |
| Acronym                                                                                                                | BALKANSGROW                                                                                                                                                                                                                                                                                                                                                                     |
| Project n°.                                                                                                            | 101242707                                                                                                                                                                                                                                                                                                                                                                       |
| Key action                                                                                                             | ERASMUS-EDU-2025-CB-VET<br>(Capacity building in the field of Vocational Education and Training (VET))                                                                                                                                                                                                                                                                          |
| Copyright<br>                       | © Partners of the BALKANSGROW Consortium, 2026.<br>This deliverable is open source and contains original unpublished work, except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation, or both. Reproduction is authorized provided the source is acknowledged. |
| <br>Co-funded by the European Union | Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.                                                                            |



## CONTENT

This training material is part of a six-module manual developed within the BalkansGrow Project. It serves as a practical guide designed to support professionals and educators in teaching sustainable farming. This specific module addresses the following topics:

|                                                                     |    |
|---------------------------------------------------------------------|----|
| 1. Introduction                                                     | 3  |
| 2. Farming Better: Soil, Climate, and Plants                        | 5  |
| 2.1. Key Concepts                                                   | 5  |
| 2.2. Current Situation and Challenges                               | 6  |
| 2.3. Best Practices and Methodologies                               | 7  |
| 2.4. Case Studies                                                   | 9  |
| 2.4.1. Rotational Grazing and Pasture Productivity in Turkey        | 9  |
| 2.4.2. Climate-Smart Upland Maize and Paddy Rice (Viet Nam)         | 10 |
| 2.4.3. Water-Harvesting through Pit Planting (Malawi)               | 11 |
| 2.5. Useful Tools and Resources                                     | 12 |
| 2.6. Practical Activities                                           | 14 |
| 2.6.1. The Soil Health Scorecard: Field Diagnostic                  | 14 |
| 2.6.2. The C/N Ratio Puzzle: Balancing the "Microbial Fuel"         | 16 |
| 2.6.2. Designing the "Collaboration Field": Functional Biodiversity | 17 |
| 3. Conclusion                                                       | 18 |
| 4. Glossary                                                         | 20 |
| 5. References                                                       | 23 |
| 6. Annexes                                                          | 26 |
| 6.1. Visualizing the "Sponge System" (Infiltration Illustration)    | 26 |



## 1. Introduction

The primary purpose of this module is to move beyond the conceptual frameworks established in the previous unit by providing a deep technical exploration of the soil-climate-plant triad, positioning their biological interconnections as the fundamental engine of a truly regenerative agrifood system. According to the Asociación de Agricultura Regenerativa Ibérica & CREAM (2026), this requires a significant paradigm shift: treating the soil not as a mere inert substrate or physical support for crops, but as a complex living ecosystem—the soil food web—on which all agricultural productivity, nutritional quality, and territorial health depend. By mastering the synergies where plants provide carbon-rich exudates to microbes in exchange for bioavailable nutrients, trainers will learn to transition management from a reliance on external chemical fixes to a system supported by internal biological processes.

This unit addresses the critical challenge posed by the 20th-century intensive agricultural model which, as noted by the FAO (2014), prioritized immediate productivity through genetics and chemistry while largely ignoring the efficiency of resources other than land. This "extractive" approach has often resulted in a "silo syndrome", where the management of crops, livestock, and forestry occurs in isolation, leading to sector competition for space and political support rather than ecological collaboration. To overcome this fragmentation, the module focuses on restoring the ecosystem services that conventional systems have historically degraded, such as natural soil formation and climate regulation. As emphasized by RegAgri4Europe (2022), upgrading the agricultural sector with these restorative skills is imperative to recognize ecological heterogeneity and empower producers to manage their land as a unified agro-ecosystem.

Upon completion of this module, the trainer will have gained the specific technical knowledge and skills to:

- Identify and evaluate qualitative indicators of soil health directly in the field—such as soil color, root abundance, and the presence of macrofauna like earthworms—allowing for rapid diagnostics without the immediate need for complex laboratory analysis.
- Understand and master the biological balance between mineralization (the rapid release of nutrients) and humification (the creation of stable soil organic matter),



specifically by managing the Carbon-to-Nitrogen (C/N) ratio required for soil microbiology to thrive.

- Apply the principles of functional biodiversity to create systems where different plant and animal species collaborate to improve global site fertility rather than competing for soluble nutrients.

In the context of global sustainable agriculture, this module demonstrates how managing the carbon and water cycles at the farm scale serves both climate mitigation (by turning soil into a carbon sink) and adaptation (by building resilience to erratic weather patterns). For the Balkan region, these interconnections are a strategic necessity due to its mountainous topography and the increasing frequency of extreme weather events. According to Gràcia et al. (2021), a soil managed under regenerative principles, rich in stable humus and protected by permanent cover, can absorb up to 150 liters of water per square meter in a single hour. This capability transforms degraded land into "sponge systems" that can effectively mitigate the risks of catastrophic flooding and prolonged summer droughts that threaten Balkan family farms.

Ultimately, Module 2 serves as the essential operational bridge within the BalkansGrow training series. It builds upon the introductory principles and global relevance established in Module 1 (Uncover the Story of Regenerative Agriculture). This unit provides the necessary biological and ecological foundations to understand the critical role of livestock in soil regeneration covered in Module 3 (Farming for the Future: Animals in Agroecosystems). Furthermore, it supplies the biophysical rationale that supports the strategies for integrating production into sustainable value chains in Module 4 (Holistic Management: Transitioning Supply Chains) and the broader professionalization of the sector explored through Module 5 (Digital Marketing in the New Agriculture) and Module 6 (Management in the Agri-sector).

## **2. Farming Better: Soil, Climate, and Plants**

### **2.1. Key Concepts**

The transition toward a restorative agricultural model requires a fundamental paradigm shift. According to the Asociación de Agricultura Regenerativa Ibérica & CREAM



(2026), soil must be redefined not as an inert physical support or a chemical substrate, but as a complex living ecosystem known as the soil food web. This community, which includes microscopic bacteria, fungi, protozoa, and nematodes along with larger macrofauna like earthworms, serves as the primary engine for biological activity, nutrient cycling, and long-term site fertility. As explained by Gràcia et al. (2021), the scientific foundation of this model is anchored in the plant-microbe symbiosis, a multi-directional relationship where plants capture solar energy and atmospheric CO<sub>2</sub> through photosynthesis to produce carbon-rich carbohydrates. A significant portion of these carbohydrates is released through the roots as exudates to feed the soil microbiology; in return, these microorganisms perform biochemical transformations that unlock minerals and fix atmospheric nitrogen, making nutrients bioavailable to the plant. This cycle of internal biological fertility is often interrupted in conventional models by the application of soluble synthetic fertilizers, which cause plants to cease exudate production, effectively "starving" the soil food web.

Within this living system, the management of organic matter is governed by two distinct biological pathways: mineralization and humification. According to Gràcia et al. (2021), mineralization is a bacterial-led process where organic materials are rapidly decomposed to provide a sudden surge of soluble nutrients for crops; however, if this process is over-stimulated through heavy tillage, organic matter disappears too quickly. In contrast, humification is a fungal-driven process that transforms organic residues into stable humus, which is responsible for the soil's long-term structure and massive carbon stocks. This biological "fuel" is managed through the C/N ratio; as noted by Gràcia et al. (2021), soil bacteria require an optimal balance of carbon to nitrogen to function without consuming existing soil carbon, which prevents the collapse of soil aggregates. Furthermore, FAO (2013) emphasizes that maintaining these carbon stocks turns the farm into a critical sink to mitigate global climate change.

The practical expression of these interconnections is the creation of a "sponge" system, where a soil rich in stable humus and protected by permanent cover can absorb and retain up to 150 liters of water per square meter in a single hour. Gràcia et al. (2021) argue that because the organic fraction of the soil is highly hydrophilic, this "sponge effect" becomes the most critical defense for the Balkan region against erratic rainfall and catastrophic flash floods. Additionally, regenerative management shifts the agricultural goal from species competition to ecological collaboration through the



principle of functional biodiversity. As highlighted by Nicholls et al. (2016), integrating diverse crop rotations and agroforestry allows different species to access nutrients at varying soil depths and share mycorrhizal fungal networks, which enhances global productivity. Finally, to monitor this functioning triad in real-time, Asociación de Agricultura Regenerativa Ibérica & CREAM (2026) and Gràcia et al. (2021) recommend utilizing qualitative soil health indicators that can be assessed directly in the field, such as a dark, earthy color signaling high humus, a crumbly structure indicating good aeration, and the presence of active vertical root growth.

## **2.2. Current Situation and Challenges**

The current agricultural landscape is defined by a critical fragmentation of the soil-climate-plant triad, which has historically been managed through a "silo syndrome". According to the FAO (2014), this approach has led to crops, livestock, and forestry being managed in isolation, causing them to compete for space and political support rather than fostering the ecological collaboration necessary for resilience. This fragmentation is a primary driver of the systemic degradation of soil health, where conventional agro-livestock production is now responsible for approximately 69 percent of global freshwater extractions (Gràcia et al., 2021).

One of the most pressing environmental challenges is the loss of the soil's physical and biological capacity to manage water. As explained by Gràcia et al. (2021), conventional management, characterized by heavy tillage and chemical dependency, has stripped soils of their stable humus, destroying the "sponge effect" required to survive extreme weather. This leaves farms in the Balkan region highly vulnerable, as degraded soils cannot absorb heavy rainfall, leading to erosion and flash floods, nor can they retain moisture during the increasing periods of extreme heat (FAO, 2018; RegAgri4Europe, 2022).

Furthermore, shifting climate patterns are directly threatening plant physiology and productivity. Zilberman et al. (2018) note that rising temperatures are facilitating the migration of pests and diseases into new niches where traditional crops lack natural defenses. Specific technical studies indicate that exposure to temperatures exceeding 30 °C is increasingly detrimental to the yields of regional staples like maize, yet many



farmers lack the adaptive tools to adjust their planting dates or switch to more resilient varieties (Ortiz-Bobea, 2018; FAO, 2018).

From an educational and operational standpoint, there is a significant skills gap in restorative management. RegAgri4Europe (2022) emphasizes that most existing agricultural training still prioritizes single-commodity intensification through external chemistry, leaving educators and farmers without the knowledge to manage the soil food web as a living engine of fertility. This lack of expertise is compounded by the "transition dip" in output; as illustrated by FAO (2018) and Gràcia et al. (2021), farmers often face a temporary fall in productivity during the first three to five years of adopting regenerative practices, as the soil's internal biological functions take time to replace the withdrawn synthetic inputs. Without institutional support or credit to bridge this gap, many producers find the transition to soil-building practices physically and economically unreachable (McCarthy et al., 2018; FAO, 2018).

### **2.3. Best Practices and Methodologies**

The implementation of best practices within the soil-climate-plant triad begins with a fundamental transition from mechanical and chemical interventions to those that prioritize the biological integrity of the soil food web. According to the Asociación de Agricultura Regenerativa Ibérica & CREAM (2026), the primary recommended technique is the total elimination of tillage, as avoiding the turning of soil layers preserves existing porosity and microbiology, which are the essential engines of natural soil formation. As explained by Gràcia et al. (2021), this must be complemented by the maintenance of permanent soil cover—using either living plants or mulch—to protect the soil surface from the kinetic energy of raindrops and to reduce evaporation. FAO (2018) notes that this combination is vital for maintaining the "sponge" capacity of the land, allowing it to function as a natural buffer against climate extremes.

The methodological procedure for adopting these regenerative practices follows a specific step-by-step sequence rooted in observation and ecological logic. According to Gràcia et al. (2021) and the Asociación de Agricultura Regenerativa Ibérica & CREAM (2026), the process must start with a qualitative field diagnostic using indicators such as soil aroma (the presence of geosmin), aggregate stability (the "cottage cheese" structure), and the abundance of macrofauna like earthworms to



establish a baseline of health. Once this baseline is understood, the next step involves managing the return of organic matter by carefully balancing the C/N ratio; producers should mix nitrogen-rich green materials with carbon-rich forest residues, such as Wood Chips (BRF) or Biochar, to reintroduce the fungal communities that are often absent in conventional systems. Gràcia et al. (2021) emphasize that this reintroduction helps structure the soil aggregate morphology, creating stable carbon stocks. Finally, FAO (2018) recommends the immediate integration of functional biodiversity through legume intercropping and multi-species rotations to provide internal nitrogen fixation and minimize the need for synthetic inputs.

For the Balkan context, these methodologies are strategically adapted to the region's specific mountainous topography and climatic vulnerabilities. Gràcia et al. (2021) argue that the application of "Keyline" design—a management system that distributes water along the terrain's natural contours—is an essential methodology for Balkan slopes to maximize rainfall infiltration and prevent the catastrophic flash floods and erosion that occur on degraded, bare soils. Furthermore, because many Balkan farms are situated near forest resources, the use of BRF (Bois Rameaux Fragmentés) produced from local forest cleaning acts as a low-cost, high-impact tool for restoring degraded land. According to RegAgri4Europe (2022), adapting these techniques requires a shift from "siloe" single-commodity thinking to an integrated agro-silvo-pastoral approach, where forest residues feed the soil and diverse plant architectures protect the crops from projected increases in seasonal heatwaves (FAO, 2018). By combining these scientific procedures with local landscape characteristics, Balkan producers can successfully bridge the "transition dip" in productivity and build long-term territorial resilience.

## 2.4. Case Studies

The following case studies illustrate the practical application of the soil-climate-plant triad in diverse geographical contexts. These examples demonstrate how regenerative and climate-smart practices can move from theoretical frameworks to operational success, effectively addressing soil degradation and building territorial resilience.



### 2.4.1. Rotational Grazing and Pasture Productivity in Turkey<sup>1</sup>

- **Background**

This case focuses on rain-fed rangeland conditions in the upland regions of Turkey. These areas share significant topographical and climatic characteristics with the Balkan region, including dry summers and soils vulnerable to compaction on sloped terrains.

- **Problem identified**

The primary challenge was low animal performance and the systematic degradation of vegetative cover due to continuous grazing (set stocking). This conventional model prevented root recovery and the humification of organic matter, leading to exposed soils, low water infiltration, and a drastic reduction in the functional biodiversity of the pastures.

- **Solution implemented**

The solution involved a transition to a rotational grazing system, where animal density is high for short periods, followed by long recovery times for the vegetation. As explained by the Asociación de Agricultura Regenerativa Ibérica & CREAF (2026), this practice simulates the natural movement of wild herds, ensuring that nutrient return via manure occurs evenly and that plants have sufficient root reserves to regrowth vigorously.

- **Outcomes**

The results showed a substantial improvement in the performance of beef cattle compared to the fixed-stocking control group. Furthermore, managing the plant cover under this regenerative regime increased soil carbon sequestration and enhanced the system's resilience to seasonal rainfall variability, transforming the pasture into a stable biomass reservoir.

- **Lessons learned**

The fundamental lesson is that controlling recovery time is more critical than the total number of animals. Planned management allows the plant-animal interaction to

---

<sup>1</sup> The information for this case study is originally presented by Thornton et al. (2018).



become a tool for internal biological fertility, reducing the need for external inputs and protecting the soil's physical structure against erosion.

#### **2.4.2. Climate-Smart Upland Maize and Paddy Rice (Viet Nam)<sup>2</sup>**

- **Background**

This case study focuses on the Northern Mountainous Region (NMR) of Viet Nam, a territory characterized by steep slopes and highly fractured topography. According to Branca et al. (2018) and FAO (2018), this region is home to ethnic minority communities whose livelihoods depend almost entirely on smallholder agriculture, specifically maize on the uplands and paddy rice in the valley floors.

- **Problem identified**

Producers in the NMR were experiencing severe soil erosion due to heavy tillage on steep slopes (greater than 25°), leading to a rapid decline in fertility and yields. Additionally, shifting climate patterns were causing "false rainfall onsets", where early rains encouraged planting followed by sudden dry spells that killed young seedlings. In the lowlands, rising seasonal temperatures were beginning to negatively affect the pollination stages of traditional rice varieties.

- **Solution implemented**

Working with the EPIC Programme, the government implemented a dual CSA strategy. For upland maize, the solution was the adoption of Minimum Tillage (MT) combined with the maintenance of crop residues as soil cover to prevent erosion and retain moisture. For rice, the project introduced Sustainable Intensification for Paddy (SIP), which included Fertilizer Deep Placement (FDP). As explained by FAO (2014b), FDP involves placing urea "briquettes" directly into the root zone (7–10 cm depth) to increase nitrogen use efficiency and reduce greenhouse gas emissions.

- **Outcomes**

---

<sup>2</sup> The information for this case study is originally presented by Branca et al. (2018) and la FAO (2018).



The adoption of these techniques led to measurable improvements in the soil-climate-plant triad. Branca et al. (2018) found that SIP was positively correlated with a yield increase of 8 percent, while the use of improved varieties further increased output by 10 percent. In areas where MT was applied, soil loss on slopes was drastically reduced, and the "sponge effect" of the residue cover allowed maize to survive early-season dry spells more effectively than conventional plots.

- **Lessons learned**

The key lesson from the NMR is that location-specific climate data is essential for determining which practices are truly "climate-smart". While sustainable practices improve profitability on average, their success is highly dependent on timing; for example, MT is most effective in years with low early-season rainfall. This underlines the need for ICT-based advisory services to help farmers match their management decisions to real-time weather forecasts.

### **2.4.3. Water-Harvesting through Pit Planting (Malawi)<sup>3</sup>**

- **Background**

In the arid and semi-arid regions of Malawi, smallholder farmers face the constant threat of food insecurity due to erratic precipitation. In this case, these farmers rely on rain-fed systems where even a short disruption in the rainy season can lead to total crop failure.

- **Problem identified**

The primary barrier to productivity was the low permeability of degraded soils. Conventional farming had left the soil surface bare and crusty, causing most rainfall to run off the land rather than infiltrating the root zone. This led to high climate sensitivity, as plants had no water reserves to draw upon during the dry spells that increasingly occur during the growing season.

---

<sup>3</sup> Information regarding this case study is provided by FAO (2018).



- **Solution implemented**

Farmers adopted a traditional water-harvesting technology known as Pit Planting (Zai Pits). This involves digging small pits (20–30 cm square and 10–20 cm deep) and filling them with a mixture of topsoil, manure, and crop residues. This technique acts as a localized "sponge", capturing and concentrating both rainwater and nutrients directly around the plant's root system (FAO, 2018; Lynch & Mkoka, 2017).

- **Outcomes**

The implementation of zai pits has transformed production in vulnerable districts. FAO (2018) reports that one study found farmers using this method in Malawi gained 79 percent higher yields than those using conventional flat-planting. By optimizing the water and carbon cycles at the micro-scale (the pit), the system allows crops to survive prolonged dry periods that would otherwise result in failure.

- **Lessons learned**

This case illustrates that low-cost, traditional knowledge can be a powerful tool for climate adaptation when combined with a scientific understanding of soil biology. According to FAO (2018) and Kaczan et al. (2013), the success of the pits depends on the "return of organic matter" (manure/residues), confirming that maintaining soil carbon is the most effective way to buffer smallholder systems against the increasing volatility of the global climate.

## **2.5. Useful Tools and Resources**

The transition to a restorative model within the soil-climate-plant triad is supported by a growing array of specialized technologies, platforms, and educational materials. These resources enable trainers and producers to move from conceptual understanding to precise, evidence-based field management.

Modern regenerative management utilizes high-resolution data to bridge information gaps at the farm scale. According to Basist et al. (2018), satellite-derived measurements of surface wetness and temperature are essential inputs for monitoring water management and predicting crop yields in near real-time, providing a superior signal of crop conditions when combined with the Normalized Difference Vegetative



Index (NDVI). To improve the precision of field-level interventions, Zilberman et al. (2018) and FAO (2018) highlight the importance of Information and Communication Technologies (ICTs), such as mobile phone-based advisory services, which deliver localized weather forecasts and market data directly to remote farming communities. On the operational level, FAO (2018) recommends the use of low-cost biological and mechanical innovations, including solar-powered electrical fences for fine-tuning grazing pressure and improved sowing machinery that enables "dry sowing" or early planting to adapt to shifting rainy seasons. Furthermore, for carbon management, FAO (2014b) describes the use of Biogeochemical Models to estimate soil carbon sequestration without the prohibitive costs of constant direct laboratory measurement.

Comprehensive technical guidance is available through several foundational manuals. The FAO (2013) Climate-Smart Agriculture Sourcebook provides a global framework for defining CSA practices and conceptual links to sustainable intensification. Specifically for field practitioners, the FAO (2018) Climate-Smart Agriculture Training Manual serves as a primary reference for extension agents, offering a two-tiered approach that combines theoretical background with practical exercises on adaptation and mitigation. For those implementing Mediterranean-style integrated systems, Gràcia et al. (2021) provide the Polyfarming System Manual, which details the design and implementation of restorative models using forest resources and directed grazing. Additionally, the Participatory Integrated Climate Services for Agriculture (PICSA) Field Manual is cited as a promising tool for combining climate information with participatory farm planning and budgeting (Thornton et al., 2018).

Also, integrated data platforms offer powerful decision-support frameworks for evaluating the tradeoffs between different management strategies. Capalbo et al. (2018) emphasize the AgBiz Logic™ platform, which includes specific modules like AgBizClimate for yield projections under alternative climate scenarios and AgBizEnvironment for quantifying changes in soil loss, carbon sequestration, and GHG emissions. For regional-scale impact assessments, Antle et al. (2018) describe the TOA-MD (Tradeoff Analysis Model for Multi-dimensional Impact Assessment), a simulation-based tool that identifies technology adoption rates and economic vulnerabilities within heterogeneous farm populations. Additionally, the RegAgri4Europe (2022) virtual learning platform provides a centralized hub for vocational training in regenerative skills, including lessons on living soils and keyline



design. Other essential global platforms include the World Bank Climate Change Knowledge Portal and the FAO Harmonized World Soil Database (HWSD), which are critical for controlling the effects of soil quality on adaptation incentives (Arslan et al., 2018; FAO, 2018).

To facilitate real-time field assessments, practitioners rely on qualitative diagnostic tools. The Soil Health Scorecard, based on criteria from Gràcia et al. (2021) and the Asociación de Agricultura Regenerativa Ibérica & CREAM (2026), allows for the visual analysis of soil aggregates, root abundance, and macrofauna without laboratory equipment. For risk management, index-based weather insurance acts as a vital supporting mechanism; as noted by Mullins et al. (2018) and FAO (2018), these products can be linked to the adoption of specific CSA techniques, providing a financial safety net that encourages innovation. Finally, farmer exchange visits in "climate analogue" areas—where current conditions mirror projected future climates for another region—serve as high-value experiential learning tools to catalyze the adoption of site-specific adaptive strategies (FAO, 2014b).

## **2.6. Practical Activities**

These practical activities are designed to translate the theoretical interconnections of the soil-climate-plant triad into observable field diagnostics and management skills. They emphasize the move from a "chemical-support" view of farming to a "living-ecosystem" approach.

### **2.6.1. The Soil Health Scorecard: Field Diagnostic**

- **Objective**

To empower participants to identify qualitative soil health indicators directly in the field, allowing for rapid diagnostics of the soil food web and its carbon sequestration capacity without immediate reliance on laboratory equipment.

- **Required materials**



Shovels, white plastic trays or tarps, water spray bottles, printed scorecards, pens, and 2-3 different soil samples from various management histories (e.g., a forest soil, a tilled field, and a permanent pasture).

- **Step-by-step instructions with time**

1. **Introduction to Visual Indicators (15 min):** The facilitator explains the technical meaning of the indicators: Color (darkness indicates stable humus/carbon), Structure (the presence of "cottage cheese" aggregates versus compact plates), and Root Architecture (vertical growth signifies healthy soil porosity).
2. **The "Spade Test" (30 min):** Participants divide into groups. In a management plot, they dig a block of soil (approx. 20x20x20 cm). They observe the distribution of aggregates and the depth of root penetration, recording findings on the scorecard.
3. **Biological Count & Aroma Test (25 min):** Soil blocks are crumbled onto white trays. Participants count earthworms and other visible macrofauna (indicators of a functioning soil food web). They perform the "smell test", identifying the sweet, earthy aroma of geosmin, which signals healthy aerobic microbial activity.
4. **Plenary Discussion (20 min):** Groups compare their "Scorecards". The facilitator leads a discussion on how different management practices (e.g., tillage versus no-till) directly caused the observed physical and biological differences.

- **Evaluation criteria**

Participants correctly identify and differentiate between "massive/compact" and "aggregated/porous" structures and accurately correlate soil color with the presence of organic matter and carbon stocks.

## 2.6.2. The C/N Ratio Puzzle: Balancing the "Microbial Fuel"

- **Objective**



To master the management of organic matter return by balancing carbon and nitrogen sources to optimize the processes of humification (long-term fertility) over mineralization (rapid nutrient surge).

- **Required materials**

Samples of local organic residues: "Greens" (fresh grass, legume cuttings, fresh manure) and "Browns" (straw, wood chips/BRF, biochar, dry leaves). Flipcharts and markers.

- **Step-by-step instructions with time**

1. **The 24:1 Principle Briefing (20 min):** Facilitator explains the biological fuel requirement of soil bacteria—the C/N ratio. If the ratio is too low, soil carbon is lost; if too high, nitrogen is temporarily "immobilized".
2. **Resource Mapping (30 min):** Groups list the organic materials available on their own farms or in their local Balkan communities (e.g., forest residues, corn stover, livestock manure).
3. **The "Mulch Mix" Challenge (50 min):** Using the provided samples, groups must design an ideal "mulch recipe" for a degraded plot. They must justify the volume of "browns" (for stability and the sponge effect) versus "greens" (for the nutrient surge) based on the target of 24:1.
4. **Group Review (20 min):** Groups present their mixes. The facilitator highlights the importance of incorporating BRF (fragmented wood) or Biochar to bridge the "transition dip" in productivity by reintroducing fungal communities.

- **Evaluation criteria**

Participants successfully design a mulch mix that avoids the risk of nitrogen immobilization while maximizing the return of stable carbon for humus formation.

## 2.6.2. Designing the "Collaboration Field": Functional Biodiversity

- **Objective**



To apply the principle of functional biodiversity by designing agroecosystems where different species collaborate to improve site fertility and water retention rather than competing for soluble nutrients.

- **Required materials**

Large farm map templates, "Plant Fact Cards" (showing root depth, nitrogen-fixing ability, and water needs of regional Balkan crops like maize, beans, and cover crops), colored markers.

- **Step-by-step instructions with time**

1. **Collaboration vs. Competition Briefing (20 min):** Discuss the technical benefits of intercropping and rotations: sharing mycorrhizal networks, varying root depths to access water, and providing internal nitrogen fixation.
2. **Agroecosystem Design Task (60 min):** In small groups, participants design a 3-year crop rotation or an intercropping layout for a local farm. The design must ensure permanent soil cover and include at least one legume-cereal synergy.
3. **The "Balkan Slope" Stress Test (30 min):** Participants must adjust their design for a hillside (steeper than 15°). They are challenged to integrate "Keyline" logic or vegetative strips to maximize rainfall infiltration (the "sponge system") and prevent erosion.
4. **Presentation (10 min):** Each group explains how their diverse plant architectures reduce the farm's sensitivity to extreme heatwaves and sudden downpours.

- **Evaluation criteria**

Inclusion of species with complementary root architectures and the presence of nitrogen-fixing legumes that demonstrably reduce the need for synthetic fertilizer.

### 3. Conclusion

The technical exploration provided in this module establishes that regenerative agriculture is not merely an alternative ideology but a scientific response to the systemic degradation of agrifood systems. The core of this restorative approach is the



recognition of soil as a complex living ecosystem, the soil food web, which acts as the primary engine for productivity and resilience. According to Gràcia et al. (2021), mastering the plant-microbe symbiosis—where plants provide carbon-rich exudates to fuel microbial activity in exchange for bioavailable nutrients—allows for a transition from high-input chemical dependency to a model supported by internal biological fertility. Furthermore, the module highlighted the technical necessity of managing the balance between mineralization and humification to build stable carbon stocks and structural integrity.

The practical relevance of these interconnections is particularly urgent for the Balkan region, where mountainous terrains and erratic weather patterns increase the risk of erosion and flooding. As demonstrated by Gràcia et al. (2021), a soil managed under regenerative principles, rich in stable humus, transforms into a "sponge system" capable of absorbing up to 150 liters of water per square meter in an hour, providing the most effective natural insurance against both flash floods and prolonged droughts. This capacity to manage the water and carbon cycles at the farm scale fulfills the three interlinked pillars of Climate-Smart Agriculture (CSA): sustainably increasing productivity, enhancing adaptation, and providing significant mitigation through carbon sequestration.

Learners can apply this acquired knowledge immediately through qualitative field diagnostics, using tools like the Soil Health Scorecard to evaluate indicators such as soil aroma, aggregate stability, and the presence of earthworms directly in the field. By applying the C/N ratio principle, producers can effectively manage the return of organic materials, balancing "green" nitrogen sources with "brown" carbon residues, to optimize the creation of humus. Additionally, trainers are now equipped to design "collaboration fields" based on functional biodiversity, utilizing species with complementary root architectures to maximize nutrient cycling and site-specific resilience. This biological foundation prepares the ground for Module 3: Farming for the Future: Animals in Agroecosystems, where the role of livestock as a specialized tool for accelerating soil regeneration will be explored in detail.



## 4. Glossary

- **Agro-silvo-pastoral System:** means a production model that integrates trees, livestock, and crops on the same land to create circular nutrient cycles and enhance ecological synergies.
- **Biochar:** means a stable, carbon-rich charcoal produced through the pyrolysis of plant biomass (heating in the absence of oxygen) that, when added to soil, improves water and nutrient retention and provides long-term carbon sequestration.
- **Bocashi:** means a fermented organic fertilizer produced through the rapid aerobic semi-decomposition of organic residues using specialized microorganisms, which simultaneously fertilizes plants and improves soil structure.
- **BRF (Bois Raméal Fragmenté):** means fragmented wood chips produced from small, fresh branches (less than 7 cm in diameter) which feed soil fungi to create high-quality, stable forest-style humus.
- **C/N Ratio:** means the numerical balance between Carbon (C) and Nitrogen (N) in organic materials; a ratio of approximately 24:1 is the "microbial fuel" required for bacteria to decompose residues without depleting existing soil carbon stocks.
- **Carbon Sink:** means any natural reservoir, such as healthy soil or growing forests, that effectively removes CO<sub>2</sub> from the atmosphere and stores it in stable organic forms.
- **Climate-Smart Agriculture (CSA):** means an integrated approach to managing landscapes that aims to sustainably increase productivity, enhance adaptation and resilience to climate change, and reduce or remove greenhouse gas emissions.
- **Cover Crops:** means specific plant species grown primarily to protect the soil surface from erosion, suppress weeds, and increase organic matter content during periods when the main crop is not present.
- **Exudates:** means carbon-rich carbohydrates and other compounds produced during photosynthesis that plants release through their roots to feed and stimulate the activity of the soil food web.



- **Functional Biodiversity:** means the strategic integration of diverse species that perform specific ecological roles (such as nitrogen fixation or deep-root water access) to move from species competition to ecological collaboration.
- **Geosmin:** means a chemical substance produced by healthy soil bacteria and fungi that gives a productive, aerobic soil its characteristic sweet, earthy aroma.
- **Humification:** means the fungal-driven biological process that transforms organic residues into stable humus, ensuring long-term soil structure and massive carbon storage.
- **Humus:** means the stable, dark-colored fraction of soil organic matter that results from advanced decomposition; it is the primary component responsible for soil's "sponge" capacity and nutrient exchange.
- **Intercropping:** means the practice of growing two or more different crops simultaneously in the same field to optimize resource use and spread climatic risks.
- **Keyline Design:** means a landscape management system that uses natural topographic contours to distribute rainfall evenly across a property, maximizing infiltration and preventing erosion on slopes.
- **Mineralization:** means the bacterial process where organic matter is rapidly broken down to release soluble nutrients; while necessary for plant growth, excessive mineralization (often caused by tillage) leads to the loss of soil organic matter and structure.
- **Mountain Microorganisms:** means a diverse community of native bacteria, fungi, and yeasts obtained directly from forest humus and used to create biofertilizers adapted to local environmental conditions.
- **Mulch:** means a protective layer of organic material (such as straw or wood chips) applied to the soil surface to reduce evaporation, suppress weeds, and buffer soil temperature.
- **No-tillage (No-till):** means a management practice that eliminates the turning or ploughing of the soil layers to preserve structural integrity, maintain microbiology, and prevent the oxidation of stored carbon.
- **Plant-Microbe Symbiosis:** means the essential multi-directional relationship where plants provide carbon energy (exudates) to soil organisms in exchange for bioavailable minerals and nutrients provided by microbial activity.



- **Soil Food Web:** means the complex community of living organisms—including bacteria, fungi, protozoa, nematodes, and earthworms—that drives nutrient cycling and internal biological fertility within an agroecosystem.
- **Soil Organic Matter (SOM):** means the total organic fraction of the soil consisting of plant and animal residues in various stages of decomposition, which serves as the primary indicator of soil health and carbon sequestration.
- **"Sponge" System:** means the physical state of a well-structured, humus-rich soil that can absorb and retain up to 150 liters of water per square meter in a single hour, protecting the farm from both floods and droughts.



## References

Antle, J. M., Homann-KeeTui, S., Descheemaeker, K., Masikati, P., & Valdivia, R. O. (2018). Using AgMIP regional integrated assessment methods to evaluate vulnerability, resilience and adaptive capacity for climate smart agricultural systems. In L. Lipper et al. (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change* (pp. 307–333). Springer.

Asociación de Agricultura Regenerativa Ibérica & CREAM. (2026). *Criterios que definen la agricultura regenerativa, consensuados por el colectivo practicante y científico ibérico*. CREAM.

Basist, A., Dinar, A., Blankespoor, B., Bachiochi, D., & Houba, H. (2018). Use of satellite information on wetness and temperature for crop yield prediction and river resource planning. In L. Lipper et al. (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change* (pp. 77–104). Springer.

Branca, G., Arslan, A., Paolantonio, A., Cavatassi, R., McCarthy, N., VanLinh, N., & Lipper, L. (2018). Economic analysis of improved smallholder paddy and maize production in Northern Viet Nam and implications for Climate-Smart Agriculture. In L. Lipper, N. McCarthy, D. Zilberman, S. Asfaw, & G. Branca (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change* (pp. 563–597). Springer.

Capalbo, S. M., Seavert, C., Antle, J. M., Way, J., & Houston, L. (2018). Understanding tradeoffs in the context of farm-scale impacts: An application of decision-support tools for assessing climate smart agriculture. In L. Lipper et al. (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change* (pp. 173–197). Springer.

FAO. (2013). *Climate-smart agriculture sourcebook*. Rome.

FAO. (2014). *Building a common vision for sustainable food and agriculture: Principles and approaches*. Rome.

FAO. (2014b). *FAO success stories on climate-smart agriculture*. Rome.

FAO. (2018). *Climate-smart agriculture training manual: A reference manual for agricultural extension agents*. Rome.



Gràcia, M., Broncano, M. J., & Retana, J. (2021). *Manual para el diseño e implementación de un modelo agroalimentario regenerativo: el sistema Polyfarming*. CREA.

Kaczan, D., Arslan, A., & Lipper, L. (2013). Climate-smart agriculture? A review of current practice of agroforestry and conservation agriculture in Malawi and Zambia. *ESA Working Paper 13-07, FAO*.

Lynch, C. & Mkoka, S. (2017). Water smart agriculture: Tools for an equitable and food secure future. *SPORE*, 187.

McCarthy, N., Lipper, L., & Zilberman, D. (2018). Economics of Climate Smart Agriculture: An overview. In L. Lipper et al. (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change* (pp. 31–48). Springer.

Mullins, J., Zivin, J. G., Cattaneo, A., Paolantonio, A., & Cavatassi, R. (2018). The adoption of climate smart agriculture: The role of information and insurance under climate change. In L. Lipper et al. (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change* (pp. 353–384). Springer.

Nicholls, C. I., Altieri, M. A., & Vazquez, L. (2016). Agroecology: Principles for the conversion and redesign of farming systems. *Journal of Ecosystem & Ecography*, S5, 1.

Ortiz-Bobea, A. (2018). U.S. Maize yield growth and countervailing climate change impacts. In L. Lipper et al. (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change* (pp. 161–172). Springer.

RegAgri4Europe. (2022). *Policy Recommendations: Upgrading the agricultural sector with skills in regenerative agriculture*.

Thornton, P. K., Rosenstock, T., Förch, W., Lamanna, C., Bell, P., Henderson, B., & Herrero, M. (2018). A qualitative evaluation of CSA options in mixed crop-livestock systems in developing countries. In L. Lipper et al. (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change* (pp. 385–423). Springer.



Zilberman, D., Lipper, L., McCarthy, N., & Gordon, B. (2018). Innovation in response to climate change. In L. Lipper et al. (Eds.), *Climate Smart Agriculture: Building Resilience to Climate Change* (pp. 49–76). Springer.



## Annexes

### 1. Visualizing the "Sponge System" (Infiltration Illustration)

Figure 1 representation (derived from data in Gràcia et al., 2021) was made to illustrate the radical difference in water absorption between degraded and regenerative soils. It demonstrates that while a tilled, bare soil might seal after only a few liters of rain, a regenerative "sponge system" can absorb up to 150 liters per square meter in one hour. This is the primary adaptation tool for the Balkan region to survive flash floods and summer droughts (Gràcia et al., 2021; FAO, 2018).

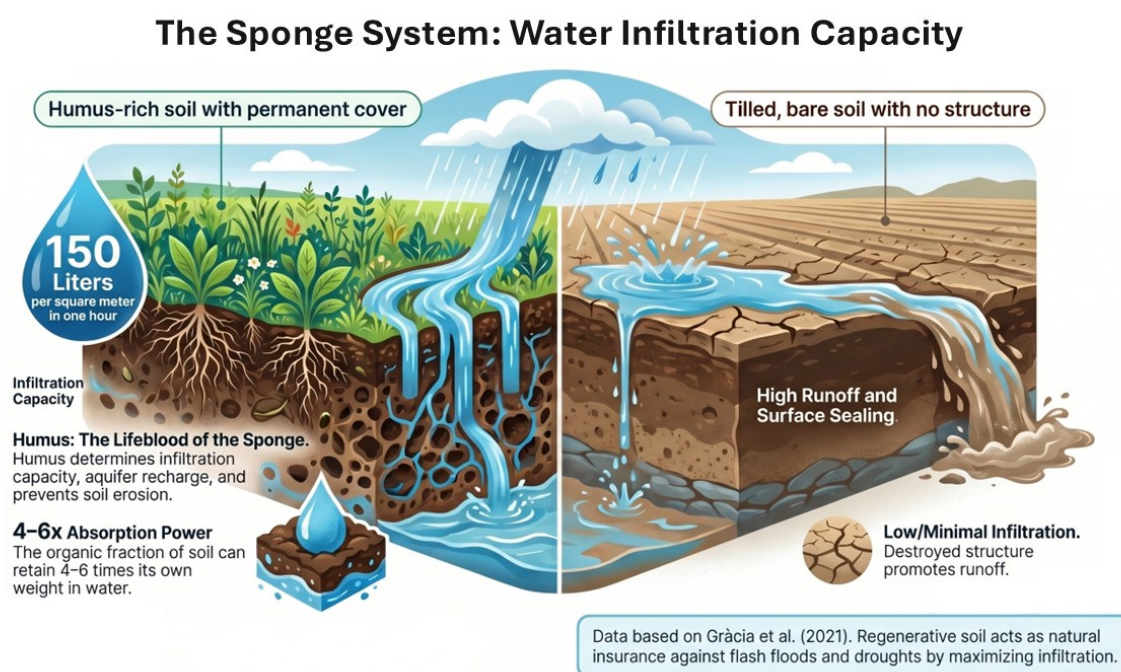


Figure 1. Water Infiltration in Degraded vs. Regenerative Soils. Author-created illustration based on Gràcia et al. (2021) showing the contrast in water absorption.



**BALKANS  
GROW**

green resilient organic wisdom



**Co-funded by  
the European Union**

## **THE BALKANS GROW PROJECT CONSORTIUM**



Univerza v Mariboru

Fakulteta za organizacijske vede

ME —  
— RA  
— KI



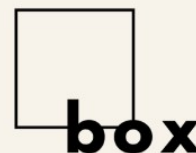
Shkolla e Mesme  
Profesionale  
Mihal Shahini



JU CENTAR ZA STRUČNO  
OBRAZOVANJE



**CRNVO**  
CENTAR ZA RAZVOJ NVO



Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.