

TRAINING MATERIAL

MODULE 3

FARMING FOR THE FUTURE: ANIMALS IN AGROECOSYSTEMS – THE ROLE OF ANIMALS IN SOIL REGENERATION AND SUSTAINABILITY



TITLE

BalkansGrow Training Material - Module 3: "Farming for the Future: Animals in Agroecosystems – The role of animals in soil regeneration and sustainability"

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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:

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1. Introduction

The primary purpose of this module is to fundamentally redefine the role of livestock within the agricultural landscape, shifting from a model that views animals as isolated production units to one where they are utilized as active biological catalysts for ecosystem restoration. According to the Asociación de Agricultura Regenerativa Ibérica & CREAM (2026), animals are not merely commodities but essential tools for increasing soil fertility and resilience. This unit moves beyond the plant-soil interactions discussed in previous modules to explore how animals, through their movement and waste, drive the nutrient and carbon cycles that are the hallmark of a truly regenerative agroecosystem.

This module addresses the challenge of biophysical fragmentation within the farm. Building upon the concept of "silo syndrome" introduced in Module 2, this unit specifically examines how the excessive separation of crops and livestock has turned a vital fertility resource—animal manure—into a significant environmental pollutant and waste management problem. As noted by Thornton et al. (2018), mixed crop-livestock systems are the global backbone of smallholder production, yet they are often poorly managed, leading to overgrazing and soil compaction. By reintegrating animals through regenerative management, producers can close nutrient loops, effectively replacing expensive fossil-fuel-based fertilizers with internal biological fertility.

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

- Implement Planned Grazing Systems: Mastering models such as Holistic Management or Voisin Rational Grazing, which use high animal density for short periods followed by long recovery times to ensure plants have sufficient root reserves to regrow vigorously.
- Optimize Nutrient Cycling: Utilizing livestock to manage cover crops and return organic matter directly to the soil through manure, which Thornton et al. (2018) note provides 15% of the nitrogen inputs for global crop production.
- Manage Animal Impact as a Restoration Tool: Learning how directed "animal impact"—the trampling and biological stimulation of the soil surface—can break up crusts, increase water infiltration, and accelerate the humification of organic residues.



In the context of sustainable agriculture, this module positions livestock management as a primary vehicle for both climate mitigation (through soil carbon sequestration) and adaptation (by building more resilient pastures). For the Balkan region, these integrated systems are a strategic priority. The region's mountainous topography and steep slopes often make mechanized cropping economically and ecologically unviable, leading to widespread rural abandonment. This module demonstrates how regenerative livestock systems can revitalize these abandoned uplands, turning them into productive carbon sinks that protect the regional water cycle.

Ultimately, Module 3 serves as the biological engine of the BalkansGrow training series. It builds directly upon the soil-climate foundations established in Module 2 (Farming Better: Soil, Climate, and Plants) by introducing the animal as the missing link that accelerates soil regeneration. This module provides the biophysical outputs—such as nutrient-dense meat, milk, and restored land—that will be integrated into the sustainable value chains explored in Module 4 (Holistic Management: Transitioning Supply Chains) and the broader professionalization of the sector covered in Module 5 (Digital Marketing) and Module 6 (Management in the Agri-sector).



2. Farming for the Future: Animals in Agroecosystems

2.1. Key Concepts

The technical foundation for integrating animals into agroecosystems rests on the fundamental shift from viewing livestock as isolated production units to utilizing them as the primary drivers of internal biological fertility. According to Thornton et al. (2018), the most robust framework for this integration is the mixed crop-livestock system, defined as operations where more than 10 percent of the dry matter fed to animals comes from crop by-products or where more than 10 percent of the total value of production is derived from non-livestock activities. Within this framework, the theoretical basis for sustainability is the synergy of nutrient and carbon cycles, which effectively addresses the biophysical fragmentation often found in conventional agriculture. As noted by FAO (2014), when crops and livestock are managed in isolation, the system suffers from a "silo syndrome" where specialized crop production depletes soil nutrients while specialized livestock production creates a surplus of manure that becomes an environmental pollutant. Reintegrating animals allows producers to close these nutrient loops; indeed, Thornton et al. (2018) highlight that livestock provide approximately 15 percent of the global nitrogen inputs for crop production through manure. When animals graze directly on the land, they perform the functions of harvesting, processing, and distributing fertility simultaneously, which significantly reduces the farm's requirements for external energy and capital (Gràcia et al., 2021; FAO, 2018).

A core concept in this restorative model is the technical implementation of planned grazing, which includes methodologies such as Holistic Management or Voisin Rational Grazing. These systems are built upon a deep understanding of animal behavior and pasture regrowth ecophysiology, utilizing high animal densities for very short periods followed by long recovery times (Gràcia et al., 2021). The central scientific principle here is that overgrazing is a function of time, not animal numbers; as emphasized by the Asociación de Agricultura Regenerativa Ibérica & CREAM (2026), if animals are allowed to remain in a plot for too long, or return before the plants have fully recovered, they consume the regrowth, which exhausts root reserves and depletes soil carbon stocks. Furthermore, the role of livestock in carbon sequestration is a vital pillar of Climate-Smart Agriculture. While ruminants are associated with



enteric methane, well-managed perennial pastures can offset these emissions by stimulating rapid plant growth that pumps atmospheric carbon into the soil profile (Thornton et al., 2018; FAO, 2014). According to Gràcia et al. (2021), the "return of materials" to the soil via livestock—through manure and trampled vegetation—is more biologically efficient than mechanical mulching because the animal's digestive tract "primes" organic matter with beneficial microbes, accelerating the humification process necessary for building stable soil structure.

The mechanical and biological stimulation provided by the herd is technically referred to as animal impact. This refers to the trampling and waste deposition that, when managed through short-duration high-density grazing, serves to break up surface crusts and facilitate the incorporation of organic matter into the soil (Gràcia et al., 2021). This concept is particularly relevant for the Balkan context, where the region's steep mountainous topography often makes mechanical tillage or mowing ecologically and economically unviable. In these landscapes, livestock function as "biological machinery", managing vegetation and maintaining soil health in areas where tractors cannot operate, which helps prevent rural abandonment and reduces wildfire risks through the clearance of forest undergrowth (RegAgri4Europe, 2022; Gràcia et al., 2021). Ultimately, these concepts converge in the agro-silvo-pastoral system, an integrated approach described by FAO (2014) and Gràcia et al. (2021) as a production model that combines trees, livestock, and crops to create circular nutrient cycles and enhance ecological synergies. By treating the animal as a restorative tool, producers can transition toward a model where biological management replaces chemical dependency, building a farm that is both productive and climatically resilient.

2.2. Current Situation and Challenges

The livestock sector currently stands at a critical juncture, characterized by a paradox of high production value and systemic inefficiency within the broader agroecosystem. According to Thornton et al. (2018), mixed crop-livestock systems are the global backbone of smallholder production, covering approximately 2.5 billion hectares and producing over 90 percent of the world's milk supply and 80 percent of the meat from ruminants. However, the historical development of these systems has been marred by



what FAO (2014) terms the "silo syndrome", where crops and livestock are managed as isolated entities. This biophysical fragmentation has transformed animal manure—a primary driver of soil fertility—into a major source of pollution; currently, manure left on pastures accounts for 16 percent of global agricultural greenhouse gas (GHG) emissions, while enteric fermentation from ruminants contributes another 40 percent (FAO, 2018).

Farmers and rural communities face immediate environmental pressures as climate change directly destabilizes animal physiology and forage availability. FAO (2018) explains that rising temperatures cause heat stress, which reduces feed intake, lowers conception rates, and increases animal mortality. Simultaneously, increased variability in precipitation leads to a reduction in both the quantity and quality of pastures, forcing farmers in regions like the Balkans to rely on expensive external feed or risk overgrazing their remaining land (Thornton et al., 2018; Gràcia et al., 2021). This degradation is particularly acute in the Balkan region's mountainous topography, where Gràcia et al. (2021) and RegAgri4Europe (2022) note that the lack of profitable, integrated management has led to widespread rural abandonment. This abandonment increases wildfire risks as forest undergrowth is no longer managed by grazing herds, leading to a cycle of ecological and social decline (Gràcia et al., 2021).

From a socio-economic standpoint, the transition to restorative livestock management is hindered by significant structural and financial barriers. A primary obstacle is the "transition dip" in productivity and income. As illustrated by FAO (2018) and Gràcia et al. (2021), producers moving from continuous to planned grazing often face an initial fall in output as they adjust stocking rates and wait for the biological functions of the soil and pasture to recover. Furthermore, the up-front investment costs for essential regenerative infrastructure—such as mobile fencing, solar-powered watering points, and animal housing—are often prohibitively high for smallholders who lack access to formal credit (Thornton et al., 2018; FAO, 2018). These challenges are compounded by tenure insecurity; FAO (2018) emphasizes that farmers without long-term, secure land rights are unlikely to invest in the multi-year process of pasture restoration that only yields significant rewards several seasons later.

Finally, there is a profound knowledge and skills gap among both producers and educators regarding the management of animals as "biological machinery".



RegAgri4Europe (2022) points out that existing vocational training often focuses on intensive, high-input confinement systems rather than the complex ecophysiology of pasture regrowth and animal impact. Many extension services remain under-funded and lack the specific expertise to advise on Planned Grazing or integrated agro-silvo-pastoral systems (FAO, 2018; Thornton et al., 2018). This lack of technical know-how means that even when farmers are willing to change, they may inadvertently cause further degradation through poor timing of grazing or inadequate manure handling, which leads to the loss of nitrogen as nitrous oxide rather than its incorporation into the soil food web (Thornton et al., 2018; FAO, 2018).

2.3. Best Practices and Methodologies

The implementation of best practices for integrating animals into agroecosystems focuses on managing livestock as active biological drivers of soil health and nutrient cycling. According to Gràcia et al. (2021), the core methodology for this integration is the transition from extensive, uncontrolled grazing to intensively controlled planned grazing. This technical approach utilizes the "animal impact"—the concentrated mechanical and biological stimulation of the soil—to break up surface crusts and incorporate organic matter, which is far more efficient than mechanical tillage for building long-term fertility (Asociación de Agricultura Regenerativa Ibérica & CREAM, 2026; Gràcia et al., 2021).

The primary recommended technique is Planned Grazing, which includes models such as Holistic Management or Voisin Rational Grazing. As explained by Gràcia et al. (2021), these models rely on the principle of high animal density for very short periods (often just 12 to 24 hours in a single plot) followed by long recovery times. This ensures that animals consume forage at its peak nutritional value without being allowed to eat the "regrowth", which would otherwise exhaust the plant's root reserves and deplete soil carbon (Thornton et al., 2018; Asociación de Agricultura Regenerativa Ibérica & CREAM, 2026).

Another vital technique is Integrated Manure Management. The FAO (2018) and Thornton et al. (2018) emphasize that manure should not be treated as a waste product but as a high-value biological amendment. Effective methodologies involve rapid



incorporation of manure into the soil food web or controlled composting/fermentation (such as Bocashi) to stabilize nitrogen and minimize methane and nitrous oxide emissions (FAO, 2018; Gràcia et al., 2021). Furthermore, agro-silvo-pastoral integration is recommended, where livestock are used to manage cover crops in orchards or to clear forest undergrowth, thereby creating a circular economy of nutrients within the farm boundaries (Gràcia et al., 2021; Soussana et al., 2015).

According to the technical frameworks provided by Gràcia et al. (2021) and the Asociación de Agricultura Regenerativa Ibérica & CREAM (2026), the methodological procedure for implementing planned grazing can follow these steps:

1. Landscape Diagnosis and Baseline Mapping: Producers must first identify their total available forage and determine the "optimum point of rest" for regional plant species.
2. Infrastructure Installation: The land is divided into permanent or semi-permanent parcels (paddocks) using mobile electric fencing (Gràcia et al., 2021; FAO, 2018). A water distribution system (e.g., mobile troughs and hoses) must be established to ensure animals have access to water in every parcel without returning to a central point, which prevents soil compaction and nutrient concentration in high-traffic areas (Gràcia et al., 2021).
3. Determining Stocking Density and Timing: Animals are grouped into a high-density herd. The duration of stay is determined by the speed of plant growth; in periods of rapid growth (spring), the herd moves faster, while in slow-growth periods (summer/winter), the return time to the same parcel must be extended—typically from 25 days in spring to 60-70 days in summer (Gràcia et al., 2021).
4. Monitoring Animal Impact and Regrowth: Producers monitor the soil surface for "impact" (trampled residues) and ensure that no plant is bitten twice during the same grazing period (Asociación de Agricultura Regenerativa Ibérica & CREAM, 2026).
5. Integration of Successive Herds: In advanced systems, a "leader-follower" model is used, where high-requirement animals (e.g., milking cows) graze the best forage first, followed by lower-requirement animals (e.g., beef cattle or sheep) to clean the remaining biomass (Gràcia et al., 2021).



In the Balkan region, these methodologies are strategically adapted to address the specific challenges of mountainous topography and rural abandonment.

- **Upland Rangeland Restoration:** On the steep slopes of the Balkans where mechanical mowing is impossible, sheep and beef cattle can be managed through rotational grazing to restore degraded grasslands. Thornton et al. (2018) and Bozkurt and Kaya (2011) highlight that rotational grazing on hilly rangelands (similar to Balkan terrain) substantially improves animal performance and soil stability compared to conventional "set stocking" (continuous grazing), as it allows the vegetation to maintain the deep root systems necessary to prevent erosion on slopes.
- **Agro-Silvo-Pastoral Systems for Fire Prevention:** Because many Balkan farms are located near forest edges, livestock can be utilized as "biological machinery" to manage forest undergrowth (Gràcia et al., 2021). By grazing cattle or goats in these areas during the slow-growth summer months, producers reduce the biomass of the "fuel load", which acts as a technical tool for wildfire mitigation while simultaneously fertilizing the forest soil (Gràcia et al., 2021).
- **Integrated Fruit and Pasture Systems:** For Balkan orchard producers, introducing sheep to manage the "living cover" between fruit trees replaces mechanical weeding and synthetic fertilization. As noted by Gràcia et al. (2021), the trees provide shade to reduce animal heat stress during increasing heatwaves (adaptation), while the sheep provide internal fertility (productivity) and stimulate soil carbon storage (mitigation), fulfilling all three pillars of Climate-Smart Agriculture.

2.4. Case Studies

The following case studies demonstrate the technical and socio-economic integration of animals as restoration tools. These examples highlight how moving from fragmented production to integrated animal-plant-soil systems can solve environmental crises while improving farmer livelihoods.



2.4.1. The Integrated Mediterranean Agro-Silvo-Pastoral Model (Spain)¹

- **Background**

According to Gràcia et al. (2021), this case study involves the implementation of the Polyfarming system in the Mediterranean mountain region of Spain. This landscape is technically characterized by abandoned uplands and steep slopes, sharing identical ecological and social vulnerabilities with the Balkan region. The model focuses on the holistic integration of forest, livestock, and crops, treating the herd as a mobile restoration unit rather than a stationary production commodity.

- **Problem identified**

The primary problem was the systemic abandonment of mountain farms, which led to the uncontrolled growth of forest undergrowth and a significant increase in wildfire risks. Simultaneously, the separation of livestock from the land meant that pastures were losing fertility due to the lack of nutrient return, while the excessive cost of external feed made smallholder farming economically unviable.

- **Solution implemented**

The solution involved utilizing livestock as "biological machinery". Producers implemented planned grazing where cattle and goats were directed into the forest undergrowth during the summer to clear biomass and reduce the fuel load for fires. Additionally, the system used a "leader-follower" grazing model in orchards, where milking cows grazed the peak-quality forage first, followed by beef cattle to manage the residues. This was supported by the installation of mobile troughs and fences to ensure that the animal impact (manure and trampling) was distributed evenly across the landscape.

- **Outcomes**

The implementation of this integrated model resulted in a significant reduction in wildfire vulnerability and a drastic drop in external fertilization costs. By returning materials directly to the soil through directed grazing, the farm practically doubled its soil organic matter in three years, transforming the land into a productive carbon sink.

¹ The data for this case study were sourced from Gràcia et al. (2021).



Furthermore, the shade provided by the integrated trees reduced animal heat stress, fulfilling the adaptation goals of Climate-Smart Agriculture.

- **Lessons learned**

The key lesson is that livestock are the most efficient tools for managing landscapes where mechanical intervention is impossible. Success depends on the control of time (rest periods) rather than animal numbers, and integrating animals with forest and fruit systems creates a circular economy at the farm scale that bridges the "transition dip" in income.

2.4.2. The Three Rivers Sustainable Grazing Project (China)²

- **Background**

This worldwide case study focuses on the Qinghai province in China, a high-altitude territory where yak and sheep herding are the primary livelihoods. The project sought to address the massive degradation of the region's grasslands through evidence-based sustainable management.

- **Problem identified**

The project identified that 38 percent of the grazing land was heavily degraded due to continuous overstocking and poor management, which led to a collapse in biodiversity and a massive loss of soil carbon. Without intervention, the herders faced a cycle of poverty as the land's capacity to support the animals diminished, leaving them vulnerable to climatic shocks.

- **Solution implemented**

The implemented solution was a package of regenerative grazing options focused on balancing grazing intensity with plant regrowth. This included the use of fenced parcels to allow for long recovery times and the introduction of winter housing and improved feeding to protect animal health during the harsh seasons. A technical innovation was the use of biogeochemical models to monitor soil carbon, allowing the project to access finance from the voluntary carbon market to cover the initial costs of the transition.

² Information for this case study was obtained from FAO (2014b).



- **Outcomes**

The project demonstrated an average annual mitigation potential of 63,000 tonnes of CO₂ equivalent per year through soil carbon sequestration. Beyond mitigation, the restoration of the "sponge system" in the grasslands significantly increased water-holding capacity, making the pastures more resilient to drought and increasing the overall productive potential of the yak and sheep herds.

- **Lessons learned**

The Three Rivers project proves that carbon markets can be a viable tool for financing the transition to regenerative livestock management. However, the most critical lesson was that herder enrollment is only successful when the practices provide direct economic returns, such as improved milk and meat yields, which creates a synergy between environmental mitigation and rural development.

2.4.3. Livestock Waste Management (China, Thailand, and Viet Nam)³

- **Background**

This regional project addressed the environmental impacts of the rapidly growing livestock sector in East Asia. As noted by FAO (2014b), population growth and urbanization in these countries created a surge in demand for animal products, leading to the emergence of large-scale intensive production.

- **Problem identified**

The project introduced a strategic framework for Livestock Waste Management (LWM) that emphasized nutrient recycling. The solution involved the adoption of new designs for approximately 500,000 pig places, incorporating technologies such as anaerobic digesters to produce bioenergy and composting facilities to stabilize manure for use as crop fertilizer. This was supported by national spatial planning to locate livestock farms where effluents could be more easily recycled onto fields.

- **Solution implemented**

³ This case study draws on information reported by FAO (2014b).



The implemented solution was a package of regenerative grazing options focused on balancing grazing intensity with plant regrowth. This included the use of fenced parcels to allow for long recovery times and the introduction of winter housing and improved feeding to protect animal health during the harsh seasons. A technical innovation was the use of biogeochemical models to monitor soil carbon, allowing the project to access finance from the voluntary carbon market to cover the initial costs of the transition.

- **Outcomes**

The project successfully reduced the negative health and environmental impacts on local water bodies while decreasing GHG emissions from manure storage. Beneficiary incomes increased as farmers were able to replace expensive synthetic fertilizers with stabilized organic nutrients and utilize biogas as a free energy source. The project also facilitated inter-agency cooperation and established a set of "Codes of Conduct" for sustainable pig production.

- **Lessons learned**

This case highlights that livestock waste is only a "problem" when the system is fragmented. By utilizing technical tools to close the nutrient loop, manure management becomes a primary pillar of both mitigation and productivity. The integration of private sector finance and government discharge standards was essential for scaling these restorative technologies.

2.5. Useful Tools and Resources

The technical integration of animals into restorative agroecosystems is facilitated by a diverse range of operational tools and digital resources. These materials provide the scientific framework for transitioning from conventional livestock production to a model where animals function as the primary drivers of internal biological fertility.

Modern regenerative management leverages data-driven technologies to monitor the complex interactions between animals and the environment. According to the FAO (2018), Remote Sensing and Satellite-derived data—particularly the Normalized Difference Vegetation Index (NDVI)—are essential for monitoring forage availability and predicting livestock mortality risks during extreme weather events. These tools



allow producers to adjust grazing intensity in near real-time, preventing overgrazing before it occurs. On the operational level, solar-powered electrical fences are highlighted by the FAO (2018) as a high-impact, low-cost technology for fine-tuning grazing pressure in planned grazing systems. For nutrient management, anaerobic digesters enable the conversion of animal waste into bioenergy while simultaneously stabilizing nutrients for use as high-value soil amendments. Furthermore, as described in FAO (2014b) success stories, biogeochemical models are now utilized to estimate soil carbon pool changes in grasslands, offering a cost-effective alternative to direct laboratory measurements for producers seeking to access environmental financing. To support herd-level decision-making, simulation tools such as LIVSIM (Livestock Simulator) model animal production based on breed-specific genetic potential and feed intake, allowing farmers to evaluate the impacts of different climate and feeding scenarios (Thornton et al., 2018).

Comprehensive technical procedures for managing livestock as restoration tools are available through foundational manuals. The FAO (2013) Climate-Smart Agriculture Sourcebook provides global principles for livestock and grazing land management, identifying interventions that offer "triple-win" benefits in food security, adaptation, and mitigation. For field-level education, the FAO (2018) Climate-Smart Agriculture Training Manual serves as a primary reference for extension agents, providing a two-tiered approach that combines theoretical backgrounds with practical exercises on manure and pasture management. For practitioners in mountainous regions, the Manual for the Polyfarming System (Gràcia et al., 2021) offers detailed protocols for implementing integrated agro-silvo-pastoral models, specifically focusing on the use of livestock to manage forest undergrowth and fertilize orchards. Additionally, the Participatory Integrated Climate Services for Agriculture (PICSA) Field Manual is recognized as a vital resource for combining historical climate data with participatory farm planning to improve livestock-related investment strategies (Thornton et al., 2018).

Integrated digital platforms provide producers with simulation capabilities to evaluate the economic and ecological trade-offs of animal integration. Capalbo et al. (2018) emphasize the AgBiz Logic™ platform, which includes specific modules like AgBizClimate for projecting the impact of temperature changes on yields and AgBizEnvironment for quantifying changes in soil carbon sequestration and



greenhouse gas emissions. For professional development, the RegAgri4Europe (2022) Virtual Learning Platform serves as a centralized hub for vocational training, offering specialized lessons on holistic grazing management and the restoration of living soils. Global climate risk profiles used by these platforms are often sourced from the World Bank Climate Change Knowledge Portal, which provides site-specific data critical for localized adaptation.

Strategic risk management and knowledge transfer are supported by a variety of practical mechanisms. Index-Based Livestock Insurance (IBLI), as detailed by Carter et al. (2018) and Thornton et al. (2018), provides a financial safety net for pastoralists by using satellite indices to trigger payouts when forage availability falls below a critical threshold, thereby preventing the asset depletion that often follows droughts. To facilitate the scaling of these practices, Farmer Field Schools (FFS) and specialized dairy farmer groups are used as incentive-based extension mechanisms to promote the adoption of climate-smart feeding and breeding techniques (FAO, 2018). Finally, Carbon Accounting Methodologies validated for sustainable grassland management are now available to help herder groups organize natural resource management and access international environmental markets (FAO, 2014b).

2.6. Practical Activities

The following practical activities are designed to bridge the gap between the theoretical principles of animal-plant-soil synergies and their technical application in the field. They focus on the management of time, animal impact, and the circularity of nutrients within restorative livestock systems.

2.6.1. The Paddock and Recovery Design Simulation

- **Objective**

To enable trainers and producers to design a rotational grazing layout that respects the ecophysiology of plant recovery and avoids the degradation and carbon loss caused by continuous stocking.

- **Required materials**



Topographic maps of a local farm (preferably with varied slopes like the Balkan terrain), tracing paper or digital mapping tools, mobile electric fencing specifications, and "Forage Growth Rulers" (showing seasonal growth speeds for regional grasses).

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

1. **Calculating the 'Optimum Point of Rest' (20 min):** The facilitator explains that overgrazing is a function of time, not animal numbers. Based on technical data from Gràcia et al. (2021), participants identify the recovery periods needed for local species during spring (rapid growth) versus summer (slow growth).
2. **Infrastructure Layout (40 min):** In small groups, participants divide a map of a degraded hillside into a minimum of 30 parcels (paddocks). They must design a water distribution system that reaches every parcel using mobile troughs to ensure the "animal impact" is not concentrated in just one area.
3. **The Grazing Calendar (40 min):** Groups create a rotation schedule. They must calculate how many days the herd remains in a parcel (e.g., 1 day) and ensure the return time matches the previously identified recovery period to allow root reserves to replenish.
4. **Peer Review (20 min):** Groups swap maps and critique the "water-flow" and "rest-period" logic, identifying potential bottlenecks for animal movement.

- **Evaluation criteria**

Participants must produce a design that ensures no plant is bitten a second time before its root reserves are replenished and demonstrates a functional water-access strategy for all paddocks.

2.6.2. Manure Valorization: From Waste to Amendment

- **Objective**

To master the technical procedures for stabilizing livestock waste to minimize GHG emissions while maximizing soil fertility through aerobic fermentation.

- **Required materials**



Samples of raw manure, finished Bocashi or compost, pH strips, thermometers, and "Manure Management Factsheets" from FAO (2018).

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

1. **Emission Identification (20 min):** Using the FAO (2018) Climate-Smart Agriculture framework, the facilitator demonstrates how raw manure left in open pits loses nitrogen as nitrous oxide (N₂O).
2. **Sensory Diagnostic (30 min):** Participants compare raw manure with stabilized organic fertilizer (e.g., Bocashi). They evaluate aroma, temperature, and moisture levels using the "punch test" (squeezing the mixture to check for correct humidity).
3. **The "Stabilization Recipe" (30 min):** Participants design a stabilization protocol for a local farm, choosing between rapid fermentation (Bocashi) or traditional composting based on available residues such as straw, biochar, or forest microorganisms.
4. **Plenary Conclusion (10 min):** Discussing how this biological management replaces the need for synthetic nitrogen, fulfilling the "productivity" pillar of CSA.

- **Evaluation criteria**

Participants correctly identify indicators of stabilized organic matter (pleasant "forest floor" smell and amber color) and explain the technical steps to reduce methane and nitrous oxide losses during storage.

2.6.3. Designing the "Living Corridor": Silvo-Pastoral Synergy

- **Objective**

To apply the principles of agro-silvo-pastoral integration to enhance animal welfare (adaptation) and soil carbon sequestration (mitigation).

- **Required materials**

Large flipchart paper, colored markers, and "Compatibility Cards" listing regional Balkan tree species (e.g., oak, chestnut, fruit trees) and livestock requirements.



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

1. **Synergy Briefing (20 min):** Facilitator discusses how trees provide shade to reduce heat stress in animals (adaptation) while animals provide directed fertility and manage undergrowth (productivity).
2. **Redesign Task (60 min):** Groups take a conventional Balkan orchard or forest edge and redesign it as a silvo-pastoral system. They must integrate "living corridors" where animals can graze between rows of trees or manage the forest floor to reduce fire risk.
3. **Impact Calculation (30 min):** Using data from FAO (2014), groups estimate the potential for increased soil carbon stocks through the combination of deep tree roots and rotational animal impact.
4. **Presentation (10 min):** Each group presents their "Living Corridor", explaining how the integration makes the farm more resilient to the extreme heatwaves projected for the region.

- **Evaluation criteria**

The design must demonstrate a functional integration where livestock management directly benefits the health and productivity of the woody species while protecting the animals from climatic stress.



3. Conclusion

The technical analysis provided in this module establishes a fundamental paradigm shift: livestock must be transitioned from isolated "production units" to active biological catalysts for ecosystem restoration. The core summary of this module highlights that the historical separation of crops and animals—often referred to as the "silo syndrome"—has led to systemic inefficiencies and environmental degradation (FAO, 2014). By reintegrating animals, producers can close nutrient loops, utilizing manure as a high-value fertility resource that currently provides 15% of global nitrogen inputs for crop production (Thornton et al., 2018). The technical engine of this transformation is Planned Grazing (such as Holistic Management or Voisin Rational Grazing), which operates on the scientific principle that overgrazing is a function of time, not animal numbers (Asociación de Agricultura Regenerativa Ibérica & CREAM, 2026). When managed with high animal density followed by long recovery periods, livestock stimulate the rapid regrowth of perennial grasses, effectively pumping atmospheric carbon into the soil profile and building stable organic matter (Gràcia et al., 2021; Thornton et al., 2018).

The practical relevance of these strategies is of paramount importance for the Balkan region. The region's challenging mountainous topography often renders mechanical management impractical, leading to a cycle of rural abandonment and increased wildfire risks due to unmanaged forest undergrowth (Gràcia et al., 2021; RegAgri4Europe, 2022). This module has demonstrated that livestock can function as "biological machinery", maintaining productivity in areas tractors cannot reach while simultaneously providing a technical tool for fire mitigation (Gràcia et al., 2021). Furthermore, the integration of animals into agro-silvo-pastoral systems fulfills the three pillars of Climate-Smart Agriculture (CSA): increasing productivity through internal biological fertility, enhancing adaptation by providing shade to reduce heat stress, and providing mitigation via soil carbon sequestration (FAO, 2018; Gràcia et al., 2021).

Learners can immediately apply the acquired knowledge by implementing field-level diagnostics and design. This includes the capacity to calculate the "optimum point of rest" for regional pastures, ensuring that herds are moved before they consume the "regrowth" that exhausts plant root reserves (Asociación de Agricultura Regenerativa



Ibérica & CREAM, 2026; Gràcia et al., 2021). Producers and trainers are now equipped to design rotational grazing layouts that utilize mobile fencing and water distribution to distribute "animal impact" evenly across degraded landscapes (Gràcia et al., 2021). Additionally, the mastery of biological manure management—through stabilization techniques like Bocashi or composting—allows for the reduction of greenhouse gas emissions while creating a potent amendment that restores the soil food web (FAO, 2018; Gràcia et al., 2021). These biological outputs and restored landscapes provide the foundational biophysical assets for Module 4: Holistic Management: Transitioning Supply Chains, where we will explore how to integrate these regenerative products into sustainable and profitable value chains.



4. Glossary

- **Agro-silvo-pastoral System:** means an integrated management approach that combines trees, livestock, and crops on the same land to maximize ecological synergies, such as using animals to manage forest undergrowth or fertilize orchards.
- **Animal Impact:** means the concentrated mechanical and biological stimulation of the soil surface caused by the trampling, movement, and waste deposition of a high-density herd, which helps break up surface crusts and incorporate organic matter.
- **"Biological Machinery":** means the strategic use of livestock to perform landscape management tasks (such as clearing vegetation or maintaining soil health) in terrains where mechanical tractors cannot operate, particularly relevant for the steep mountain slopes of the Balkan region.
- **Bocashi:** means a fermented organic fertilizer produced through the rapid aerobic semi-decomposition of organic residues using specialized microorganisms, often used as a technique to stabilize manure and enhance soil fertility.
- **Carbon Sequestration:** means the process by which atmospheric carbon dioxide is removed and stored in long-term reservoirs, such as woody biomass or stable soil organic matter, often enhanced by well-managed perennial pastures.
- **Carbon Sink:** means any mechanism or natural reservoir, such as a growing forest or a regenerative soil system, that effectively removes greenhouse gases from the atmosphere and stores them.
- **Enteric Fermentation:** means the natural digestive process in ruminants (such as cattle and sheep) that produces methane as a byproduct; these emissions can be significantly reduced by providing high-quality, more digestible forage.
- **Humification:** means the biological process, often accelerated by the "priming" of organic matter in an animal's digestive tract, that transforms residues into stable soil humus, building structural integrity and long-term carbon stocks.
- **Integrated Manure Management:** means the strategic handling of animal waste to close nutrient loops, involving the stabilization of manure through



composting or controlled fermentation to minimize the loss of nitrogen as nitrous oxide.

- **Mixed Crop-Livestock Systems:** means production models where crops and animals are raised on the same farm, allowing for the efficient exchange of resources like manure for fertilizer and crop residues for feed.
- **Nutrient Loops:** means the circular flow of nutrients within an agroecosystem where livestock and crops support each other's productivity, effectively replacing external synthetic inputs with internal biological fertility.
- **Optimum Point of Rest:** means the critical stage in pasture regrowth where a plant has recovered its root reserves and reached a balanced nutritional value, marking the ideal moment for animals to enter the paddock.
- **Overgrazing:** means a phenomenon caused by the factor of time—not animal numbers—where animals remain in a paddock for too long or return too soon, consuming the "regrowth" of plants and exhausting their vital root reserves.
- **Planned Grazing:** means a management methodology (such as Holistic Management or Voisin Rational Grazing) that uses high animal densities for short periods followed by long recovery times to stimulate vigorous plant growth and restore soil health.
- **Recovery Time:** means the essential duration that a pasture must remain free of livestock to allow plants to pass their phase of maximum growth and replenish root reserves before the next grazing event.
- **"Silo Syndrome":** means the technical and institutional fragmentation resulting from the excessive separation of crops, livestock, and forestry, which turns potential resources into waste problems and environmental conflicts.
- **Stocking Density:** means the concentration of a specific number of animals on a particular area of land at a given moment, used as a tool in planned grazing to achieve uniform animal impact and prevent selective grazing.



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Annexes

1. Ecosystem service flow

Figure 1 representation, adapted from Spratt et al. (2021), illustrates regenerative grazing as a “win-win-win” component of regenerative agriculture. This approach applies soil-health principles and adaptive livestock-management strategies to enhance farm profitability, improve human and ecosystem health, and strengthen the resilience of food systems. By integrating planned grazing practices with ecological processes, regenerative grazing contributes to healthier soils, increased biodiversity, improved water retention, and greater climate resilience, while maintaining productive and economically viable livestock operations.

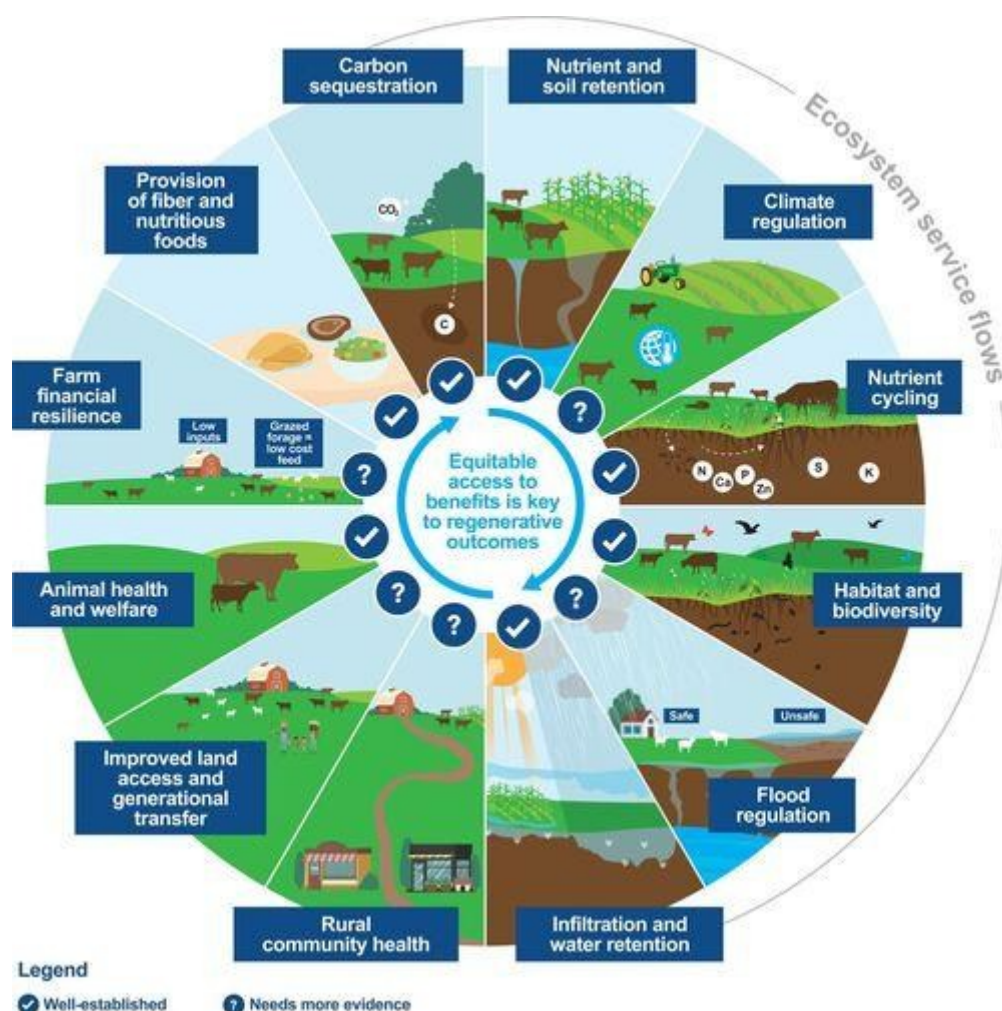


Figure 1. Regenerative Grazing as a “Win-Win-Win” Strategy. Author-created illustration adapted from Spratt et al. (2021) showing regenerative grazing as a triple-benefit component.



2. Biological manure management

This illustration in Figure 2 highlights key components of biological manure management, including farmyard manure, compost, green manure, poultry manure, and vermicompost. These organic inputs support natural soil fertility by enhancing microbial activity, increasing organic matter content, and improving nutrient cycling. Through biological decomposition processes, they release essential nutrients gradually, improve soil structure and water retention, and promote healthy root development. Effective biological manure management reduces reliance on synthetic fertilizers, supports biodiversity in the soil ecosystem, and contributes to resilient and sustainable agricultural production systems.



Figure 2. Components of Biological Manure Management. Author-created illustration showing key organic inputs used to enhance soil fertility through biological processes.



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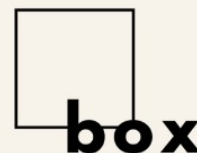
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