DRYLAND AGROFORESTRY: INSIGHTS FROM CENTRAL ANATOLIA

November 2025

OVERVIEW

About this brochure

This brochure was developed for TransforMed, a project supporting large-scale agroforestry adoption in saline, degraded Mediterranean areas to restore soil health, biodiversity, and productivity.

This document offers an introduction to Agroforestry Systems (AFS), complemented by field-based insights from the cold semi-arid continental regions of the Central Anatolian Plateau in Türkiye. The theoretical inputs and selected success stories aim to increase awareness of AFS's benefits and pave the path to widespread adoption in the semi-arid Mediterranean.

The drafting of this document is based on a non-exhaustive selection of the available literature on agroforestry practices in the Mediterranean region. Furthermore, only a limited part of the local and traditional knowledge about linking trees, crops, and animals could be addressed. This document is intended as an exploratory effort to bring together scientific and empirical content, to make it accessible to a broader audience.

Targeted readers

This guide is a practical resource for farmers, extension officers, local communities, and other stakeholders interested in the understanding and the application of agroforestry practices in the semi-arid Mediterranean region or in the cold semi-arid regions of Central Anatolia.

About the context

In Central Anatolia, precipitation is scarce and highly seasonal, with long dry summers and most rainfall occurring in late autumn and spring. Winters are cold and often snowy, though snow cover has declined as a result of climate change. The region experiences significant temperature fluctuations between seasons and even between day and night. Frequent windstorms on the plateau significantly contribute to soil erosion and evaporation.

Such environmental conditions pose significant challenges to plant development and animal life. Yet these landscapes are far from being barren or uninhabited. They host diverse ecological systems that are well adapted to harsh climatic conditions.

Agricultural systems across Central Anatolia face similar threats to those in other Mediterranean-influenced regions; challenges intensified by climate change and intensive resource management: soil degradation, depletion of water resources and land pressure, loss of biodiversity, desertification, and rising vulnerability to extreme weather events.

To address these major challenges, a strategic shift toward more ecological and resilient agricultural practices is essential. This shift involves better water use, soil regeneration techniques, and the integration of crops and trees adapted to the local context, while preserving traditional practices such as dryland farming and pastoralism.

In this perspective, agroforestry emerges as a set of both technical and social practices that can help address these challenges by optimizing local knowledge and resources.

What is agroforestry?

Agroforestry is a modern term for the ancient practice of integrating trees or shrubs into agricultural systems. This approach has been historically used in traditional agricultural systems such as silvopastoralism and the use of windbreaks to protect crops. Today, agroforestry is not only a practice but also a growing research field, from which a strong body of evidence shows the multiple ecological, economic, and social benefits of the practice.

The two defining criteria of agroforestry are [1]

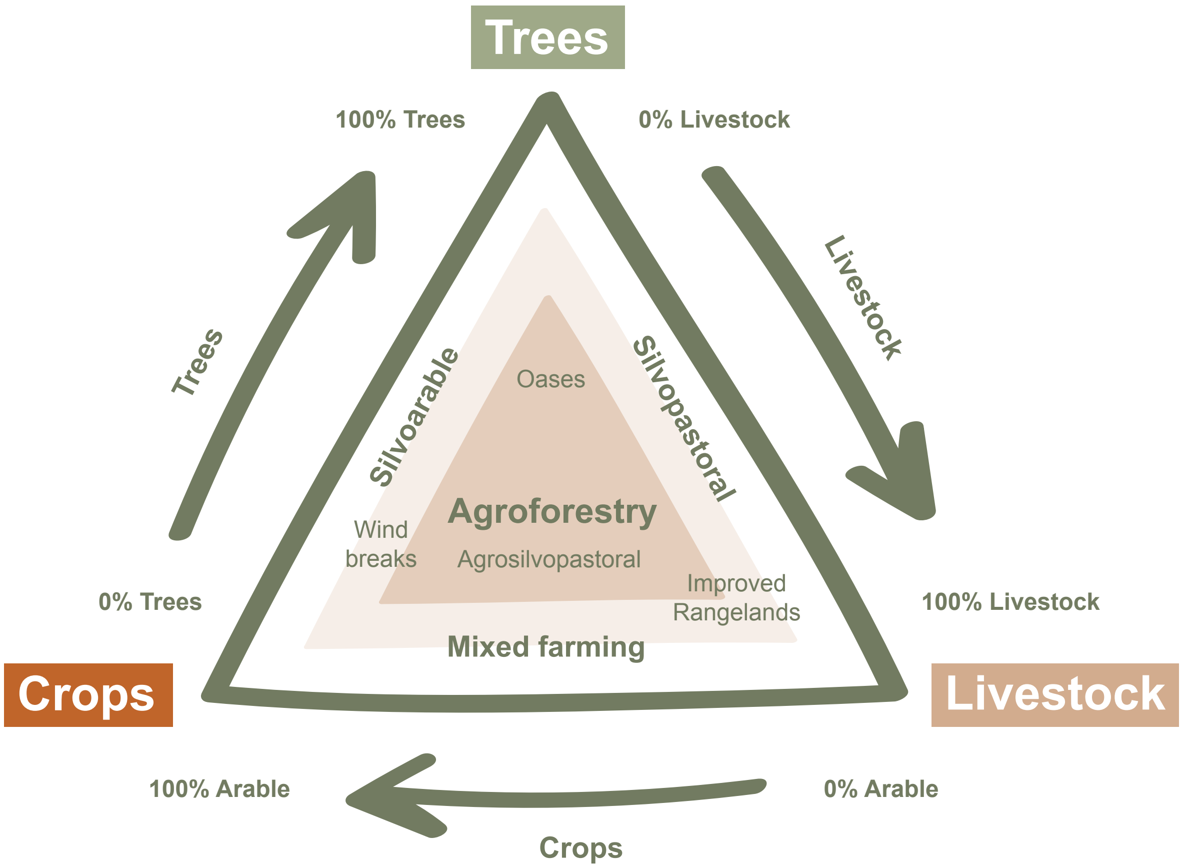
- The intentional coexistence of trees and crops and/or livestock, in space and/or time;
- The presence of significant ecological and economic interactions between trees and crops, and/or livestock.

Agroforestry TransforMed project definition

It is a collective name for land-use systems and technologies in which woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately combined on the same management unit with herbaceous crops and/or animals, either in some form of spatial arrangement or temporal sequence. In AFS there are both ecological and economic interactions among the different components [2].

Agroforestry triangle

Agroforestry involves the integration of trees and/or shrubs with agricultural crops and/or livestock. These combinations form a system rich in a gradient of interactions. The system remains flexible, and its components can change over time, giving rise to new practices.



Agroforestry system overall output [3]

Productivity

Integrating trees into farmland can enhance overall productivity while offering extra sources of on-farm income, such as fodder, firewood, timber, or fruit.

Water management

Incorporating trees and other perennials contribute to water regulation. It can slow surface runoff, which helps to moderate downstream flooding and reduce soil erosion. Additionally, the deep roots of well-placed trees can limit **nutrient leaching**[1] while improving soil moisture.

Animal welfare

Introducing trees into pastoral land can help moderate temperature extremes and create more diverse within-field habitats, which in turn can reduce animal stress.

Biodiversity & Pest control

The introduction of trees and shrubs significantly increases species diversity, creating new habitats, and attracting beneficial insects and birds that aid in natural pest control.

Tackling climate change

Trees and other woody perennials can moderately influence the farm's microclimate and contribute to improve air quality, and enhance carbon sequestration both above and below ground.

Livelihoods & Wellbeing

A diversified agroecosystem supports livelihoods by providing a staggered income throughout the year and reducing workload peaks through a more balanced distribution of tasks across seasons. It also strengthens economic resilience, helping farmers remain viable even if one crop fails.

[1] Words shown in bold and color are explained in the glossary at the end of the brochure

Water management, a major challenge for dryland agriculture

Water is a fundamental component in agriculture. It becomes even more crucial in the arid and semi-arid context being addressed here. In dryland agriculture, water management is one of the main challenges. For hundreds of years, farmers have developed several traditional systems to collect, channel, and conserve water [4] for later use in irrigating crops or providing drinking water for humans and animals.

From a medium- and long-term perspective, the integration of woody perennials in the agrosystem leads to improved soil water services such as easier water infiltration, drawing water from deeper zones, reducing water loss by runoff and maintaining moisture [5,6]. These processes, while effective and beneficial for surrounding crops, require targeted management and good knowledge of the selected species.

To introduce trees and shrubs into an agricultural system in arid and semi-arid areas, farmers must have access to water and irrigation methods. These two criteria are essential. Water is required at least during the first two years of system establishment, and depending on the species, for several more years during dry periods. In the planting phase, water management should be combined with practices that enhance soil water use efficiency, such as water harvesting techniques and the addition of soil organic matter like compost and manure.

Once the trees have developed a root system capable of accessing deeper water, the aforementioned beneficial effects will take place.

Watering newly planted seedlings (Morocco)

Types of agroforestry systems

Agroforestry systems (AFS) do not show clear boundaries between them but rather a gradient determined by the proportion in which the three elements are used, as seen in *The AF Triangle (Page 4)*. Similarly, AFS are not static in time and can evolve, according to management, to integrate new elements or change the proportion of their use. For example, a silvopastoral system can turn into an agro-silvopastoral system if crops are introduced. Thus, AFS can also alternate in time, for example, during fallow periods. Each AFS is dependent on contextual components such as climate, ecology, resource availability, and cultural aspects.

Silvoarable

Widely spaced trees intercropped with annual or perennial crops, or **coppice.**

Examples
Alley cropping, orchard intercropping, individual trees (different species), and multifunctional **pollarded** trees.

Orchard of almond and olive trees with intercropping of cereals or faba beans (Tunisia)

Silvopastoral

A combination of trees and shrubs with fodder crops and/or pastures for animal production.

Examples
Shelterbelts (for protection and/or fodder), riverside grazing and hedgerows, grazed orchards, silvopoultry, parklands or **wood pastures,** forest grazing.

Goats grazing and crossing shrub-covered slopes (Morocco)

Agro-silvopastoral

Agrosilvopastoral systems integrate crops in addition to trees with forage and animal production.

Examples
Livestock grazing fields after harvesting, fruit trees and livestock in a field, and trees alongside grazing land.

Sheep grazing under peach orchard trees (France)

Hedgerows, windbreaks, and riparian buffer strips

Lines of natural or planted perennial vegetation (tree/shrub) bordering croplands/pastures and water sources to protect livestock, crops, and/or soil and water quality.

Examples
Shelterbelt networks, wooded hedges, fodder hedges, forest strips, riparian tree strips

Tree windbreaks along cereal fields, composed of oaks, black pines, ashes, and almonds (Türkiye)

Syntropic agriculture (previously successional agroforestry)

Syntropic agriculture is a land-use system inspired by natural succession and stratification.
It integrates diverse endemic or adapted species in layered arrangements to optimize photosynthesis, biomass production, and soil regeneration. By maintaining permanent soil cover, promoting dense planting and pruning, and organizing plant growth in space and time, syntropic systems restore soil fertility, enhance biodiversity, and deliver resilient, high-yield production with minimal external inputs [7].

High diversification and biomass production in a syntropic plot (Portugal)

How can agroforestry contribute to the restoration of degraded drylands?

Degraded lands

Degraded lands are essentially areas where human activities, and indirect forces such as climate change, have diminished soil fertility and the land's capacity to support ecosystems, biodiversity, and human livelihoods.

Common outcomes include reduced yields, soil erosion, loss of vegetation, water scarcity, and general ecosystem decline.

Drylands, such as those in the Mediterranean semi-arid and arid regions, are the most vulnerable areas to human pressure and climate change effects. Year by year, several regions are losing arable land due to soil degradation.

A definition from the Intergovernmental Panel on Climate Change (IPCC)

Land degradation is defined as a negative trend in land condition, caused by direct or indirect human-induced processes including anthropogenic climate change, expressed as long-term reduction or loss of at least one of the following: biological productivity, ecological integrity, or value to humans.

Land degradation affects people and ecosystems throughout the planet and is both affected by climate change and contributes to it [8].

In degraded drylands, carob plantations help stabilize soil and facilitate herbaceous growth (Morocco)

Visual evidences of soil erosion (Morocco)

Agroforestry as a land restoration process

The way to reverse the land degradation trend is long and requires perseverance and nature-based actions in order to regenerate the soil system. Agroforestry techniques, such as alley cropping with tree species, living fences, mulching, and the addition of tree and bush biomass to the soil, can significantly contribute to the restoration of degraded areas. These strategies not only improve soil structure and fertility, but also enhance the resilience in the face of extreme events.

AFS are complex and involve interaction between different components. At the field level, the challenge is to select and manage all of the components to minimize competition while maximizing positive interactions, thus ensuring a gradual optimization of the resources *(Figures 1 & 2).*

The design of the AFS, the choice of tree and shrub species, their spatial arrangement, and their management are essential aspects of its successful implementation.

Hilly plots interplanted with cactus in rows for soil stabilization and agricultural diversification (Tunisia)

Agroforestry system services & interactions

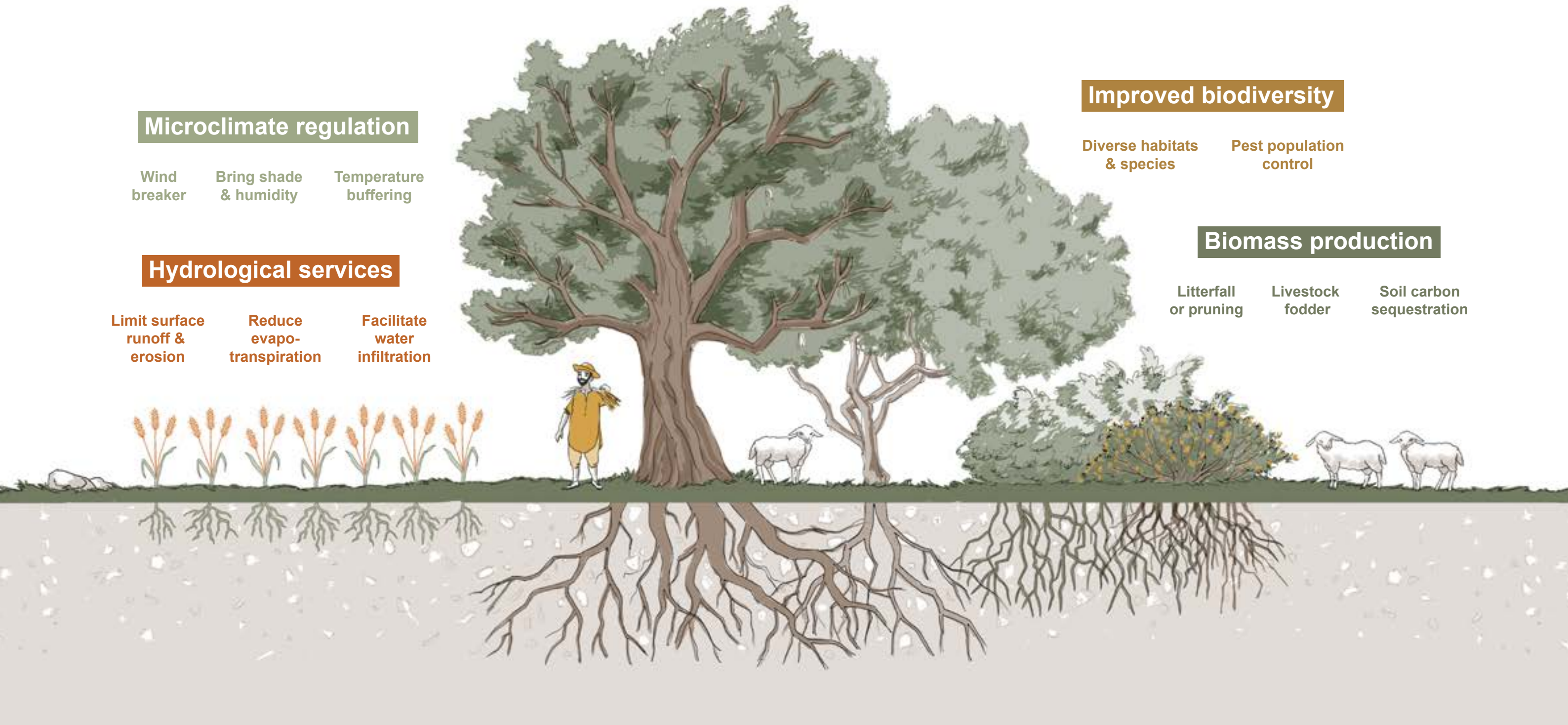


Figure 1: The integration of trees and shrubs into farming systems delivers ecosystem regulation services and additional resources.

Field level

Soil

Improved water quality and availability

The root systems of trees hold the soil in place and improve soil structure, which allows water to infiltrate into the soil instead of washing the soil away.

The canopy of the trees also intercepts the rain, serving as a natural protection for the soil against the erosive effect of the raindrops, allowing it to infiltrate more slowly and deeply into the soil.

Depending on the depth of the water table, some tree species have root systems that can access groundwater and redistribute it to upper soil levels through a process called **hydraulic lift.** This phenomenon may contribute to reducing the water stress for nearby crops during dry periods.

Farmers must closely monitor the water needs of trees throughout their life cycle, in particular during the first years. The implantation period is decisive; depending on the climate and species, watering may be required during the first 2-4 years. To avoid competition for water with crops, it is essential to plan: consider tree-crop spacing, root system architecture, and seasonal timing (e.g., pairing deep-rooted trees with winter or summer crops, or using short-cycle forage crops).

Nutrient cycles and biological activities

The roots of trees and shrubs can draw nutrients from deeper layers of the soil. When parts of the woody perennial (leaves, twigs, bark, or fruit) fall on the soil or are deliberately pruned, they decompose. Additionally, the growth and the dieback of the roots, as well as the roots' exudates, enrich the soil with carbon compounds. The breakdown of this organic matter improves soil structure, enhancing water and nutrient retention, and reducing leaching.

In well-managed soils, beneficial bacteria and **mycorrhizal fungi** thrive, boosting nutrient and water availability for plants. These **symbiotic associations** enhance nutrient flow between trees and crops.

To limit root competition, careful planning is essential. Planting crops at the right time encourages trees to develop deeper root systems, leaving enough space for crops to grow. This ensures that both trees and crops can access the nutrients they need. Moreover, introducing any new species should be preceded by a careful study to verify its compatibility with existing plants and its ability to thrive in the specific soil conditions of the region.

Nitrogen fixation

Leguminous trees and shrubs (such as carob or black locust) can convert atmospheric nitrogen into forms that can be absorbed by plants. In the rhizosphere of these species, and through the action of nitrogen-fixing bacteria associated with their roots, nitrogen from the air is captured and made available in the soil (atmospheric **nitrogen fixation**).

Although the exact process of nitrogen redistribution within the soil is not yet fully understood in the scientific literature, it appears that the nitrogen-fixing plants are the first to benefit from the fixed nitrogen, with only a small portion being released into the surrounding soil.

To introduce nitrogen-rich organic matter into the soil effectively, the most efficient method is to prune the branches and leaves of nitrogen-fixing species (trees, shrubs, or herbaceous plants) and apply the biomass directly to the soil surface, or incorporate it into the soil. This practice helps to both cover the soil, thus preserving moisture, and enhance soil fertility.

Light management

The spacing and orientation of plantings are critical for optimizing sunlight distribution among species. Shade-tolerant crops should be prioritized for lower strata, ensuring that each plant receives light according to its specific needs. In addition, careful selection of species and varieties is essential in arid contexts where solar radiation can be extremely intense during certain periods of the year.

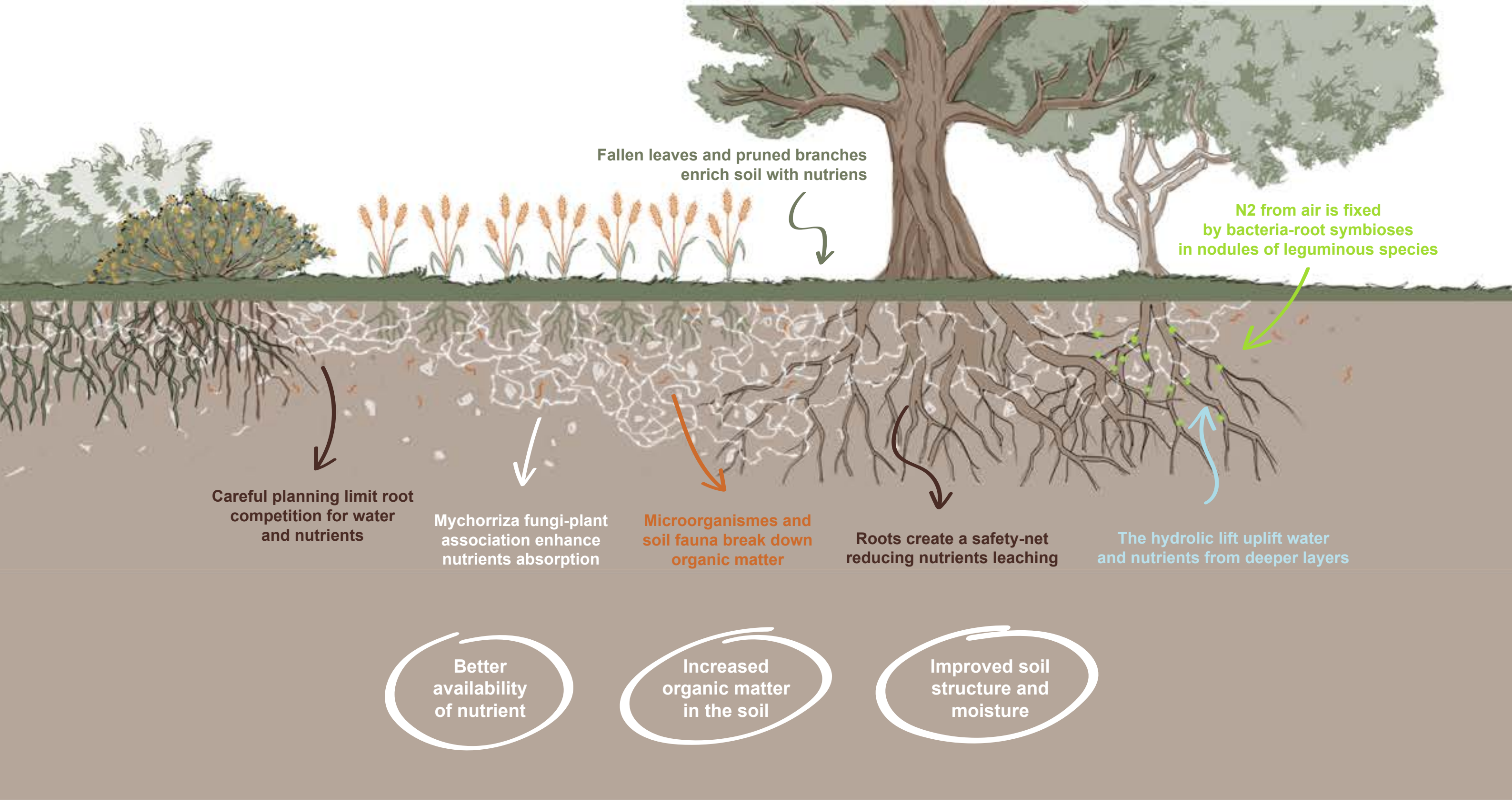


Figure 2: Plant-soil dynamics in AFS.

Landscape level

Microclimate effect

At the landscape scale, trees and shrubs help stabilize the microclimate by reducing evapotranspiration, moderating temperature fluctuations, and lowering wind speed. At broader scales, their evapotranspiration can raise atmospheric humidity and potentially influence rainfall patterns, leading to increased precipitation.

Temperature buffering

The cooler microclimate and shade that trees and shrubs provide reduces heat stress for crops and livestock during climate extremes. This is particularly beneficial for crops such as wheat, which are sensitive to extreme temperature changes during critical growth stages such as pollination. Likewise, trees and shrubs create a protective buffer for extreme cold. At night, the canopy reduces heat loss from the ground by trapping warm air beneath it, which helps prevent frost damage in colder seasons.

Wind and humidity regulation

Trees can also reduce wind speeds in agricultural landscapes, thereby protecting crops and animals, reducing water loss and preventing soil from being blown away. Although, depending on their layout, windbreaks may create heat islands or areas of stagnant humid air, which can lead to the emergence of fungal diseases.

Biodiversity, pollination, and natural pest control

The integration of trees and shrubs with crops creates diverse habitats that support a wider range of species.

For farmers, this is particularly relevant in terms of pollinators. Trees and shrubs can increase the pollinator population due to the higher availability of flowering plants. Trees and shrubs also offer nesting habitats for pollinators and other beneficial insects, as well as birds that can control pest populations (**auxiliary species**). By promoting natural pest control, AFS can reduce the need for chemical pesticides.

Biodiversity also increases in the below-ground components of the system. Healthier soils are more likely to be colonized and inhabited by a rich community of macro- and micro-fauna, as well as beneficial bacteria and fungi.

Farmers' livelihood and wellbeing

Diversification and resource optimization

An optimized AFS can significantly enhance livelihoods by increasing overall productivity through the diversification of outputs on a single plot at different times of the year. In addition to the primary crop, trees and shrubs can yield animal fodder, food products (such as fruits and nuts), medicinal resources, firewood, or timber – each representing a potential source of income. This diversity contributes to improved food security, as it buffers farmers against total crop failure due to pests, diseases, or extreme weather events.

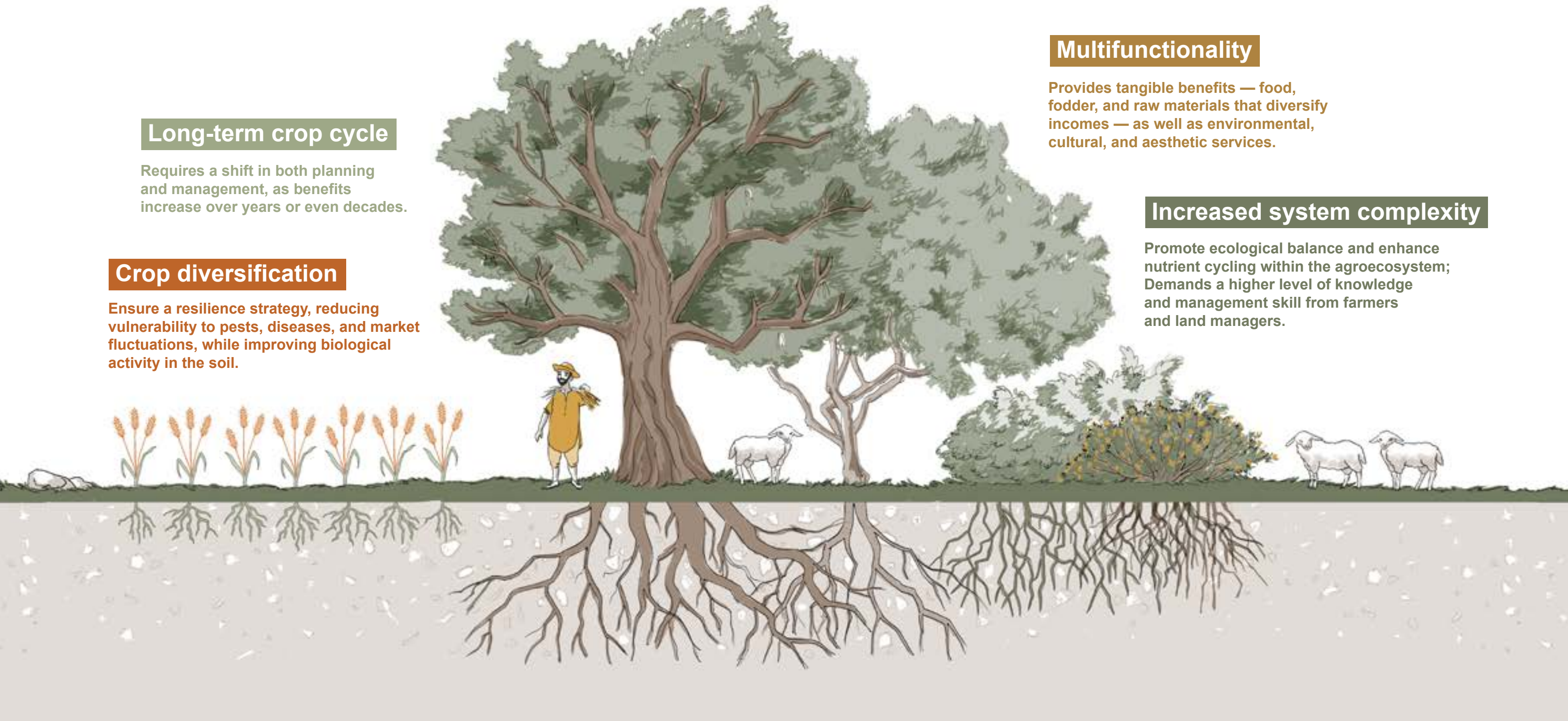


Figure 3: Agroforestry adoption delivers lasting economic, environmental and social benefits.

Managing complexity

The complexity of managing multiple interdependent components in the agroecosystem introduces notable challenges for smallholder farmers. The workload, particularly during the establishment and early management phases, can be considerable, and is often compounded by constraints such as limited access to water, suitable equipment and tailored financing, insufficient public and private sector support, scarcity of high-quality plant material, shortages of labour, and insecurity in land tenure.

Socioeconomic dimension

At the social level, AFS can have varied impacts. On one hand, they can enhance farmers' satisfaction by improving the functionality and aesthetics of agricultural landscapes. Some AFS are even recognized as Globally Important Agricultural Heritage Systems (GIAHS), which can inspire neighbouring farmers and trigger a positive ripple effect. On the other hand, AFS implementation may face resistance or cause conflicts, particularly in areas dominated by conventional farming or where tree planting is perceived as limiting land access. As a (re)emerging approach, the adoption of new AFS should be designed to engage as many beneficiaries as possible and supported by clear explanations to facilitate their implementation.

Finally, from a socioeconomic perspective, AFS can create inclusive economic opportunities, such as establishing new cooperatives at local and regional levels and developing value chains for emerging products. These initiatives can empower communities and increase job opportunities for rural inhabitants.

Carbon storage and climate change mitigation

More generally, trees and shrubs can sequester carbon by storing it in their trunks, branches, leaves, and roots for long periods. They can also affect the rate of soil organic matter decomposition by lowering soil surface temperature, thereby contributing to climate change mitigation.

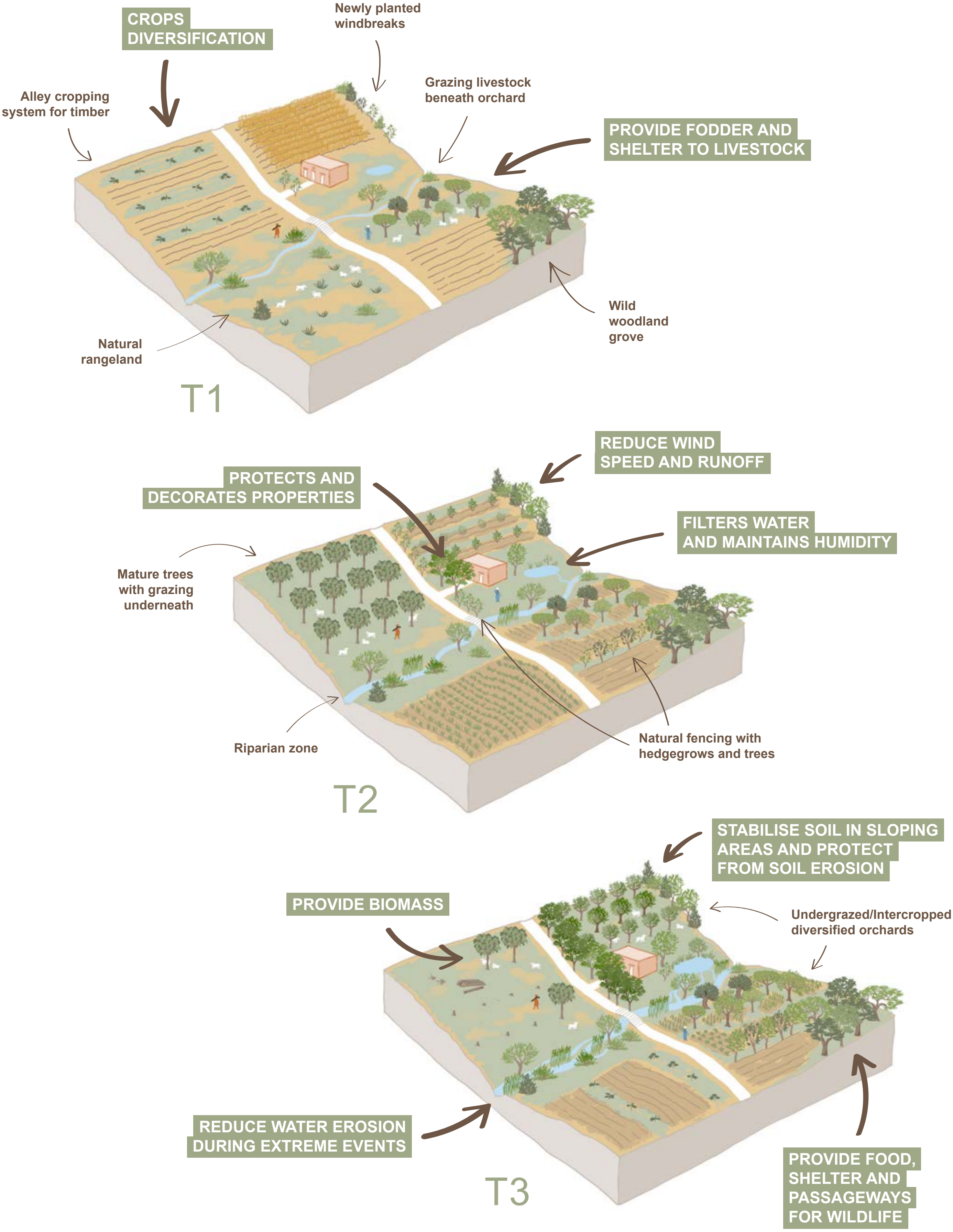


Figure 4: Evolution over time and space of diverse agroforestry systems at the landscape level. As time (T) passes (from T1 to T3), the landscape is transformed and the role of trees also evolves, reshaping the territory and its interactions with other components of the system (livestock, crops, habitat, etc.).

Examples of agroforestry system in Central Anatolia

TransforMed Case Study

Altinova Governmental Farm, Konya, Türkiye

Type of agroforestry system

Windbreaks

Site description

Altınova farm is situated on the Central Anatolian Plateau, in the Kadınhanı District of Konya Province, Türkiye. This expansive site covers a total of 31,026 hectares at an average elevation of 950 meters above sea level. The local climate is continental, characterized by distinct seasonal temperature fluctuations, limited rainfall averaging 315 mm per year, and dominant steppe vegetation. The bulk of precipitation falls in winter, spring, and autumn, with May being the wettest month and August the driest. With an annual average temperature of 11°C, winters are cold, and summers are hot and arid. The site is also subject to strong southerly windstorms reaching 120 km/h, and experiences 20 snow-covered days annually, with frost possible from late September to mid-May.

Established originally as a public enterprise in 1942 on previously vacant treasury land, the Altınova site continues to serve under the Ministry of Agriculture. The farm is primarily used for seed production and animal husbandry. The agricultural production system at Altınova farm mirrors the practices of many dryland farmers in the region, relying mainly on a two-year rotation of fallow and winter cereals such as wheat or barley. Conventionally cereals agriculture make use of intensive tillage practices, leaving the soil vulnerable to wind erosion, an issue that became pronounced in the 1960s when the area transitioned from natural pasture to arable land. In response, windbreaks were established, particularly to counter the damaging southern and northern winds. Today, these windbreaks have proven crucial, not only in significantly reducing soil erosion but also in enhancing crop yields, supporting local biodiversity, and in reducing pesticide use. In less suitable areas for cereal cultivation, almond trees have been planted; these trees, though largely unirrigated, have demonstrated resilience by producing fruit even under dry conditions, though labour shortages have limited their harvest.

Agroforestry practices implemented

- **Windbreaks/Agroforestry belts:** planting of tree lines (including almond trees) to protect against wind erosion, support biodiversity, and create microclimates.
- **Integration of non-irrigated almond trees in marginal areas:** almonds orchards provide productivity from less suitable cereal-growing land
- **Stubble grazing and rotation with cereal crops (mixed farming):** while not a classic agroforestry system, the integration of crop-livestock systems enhances ecosystem services.
- **Landscape-level approach:** the blend of seed production, cereal crop rotation, pasture, and forested windbreaks forms a multifunctional agroecosystem.
- **Land rehabilitation:** where land is no longer suitable for crops, planting trees and shrubs provides soil cover and biomass, gradually regenerating degraded plots.

Replicability in a similar context

The Altınova site exemplifies both the possibilities and challenges associated with large-scale dryland farming under continental climate conditions. The successful establishment and maintenance of windbreaks stand out as a replicable model for combating erosion, supporting biodiversity, and improving microclimates.

Other Example from Central Anatolia

Improved Rangelands, Burunoba, Türkiye

Type of agroforestry system

Improved rangelands, silvopastoral system

Site description

The village of Burunoba, located on the semi-arid plains between Karapınar (Konya) and Karaman, sits at around 1,000 meters elevation. The area is part of the Konya Closed Basin, characterized by hot, dry summers, cold winters, and low, irregular rainfall, averaging only 300 mm annually. Soils are mostly calcareous and sandy loams, poor in organic matter, and highly prone to wind erosion, which expose the region to severe land degradation.

Overgrazing, coupled with recurrent drought, has reduced the natural vegetation cover and left rangelands fragile and unproductive. Additional, lack of state support for investments in drought resistant crops, water management, as well as in non-irrigated agriculture technics, is leading to a dramatic depletion of the available water resources.

Local administrators and farmers are strongly concerned by this context and are now exploring solutions to implement at local level. As such, windbreaks and trees strips have being adopted in some plots, and other will be planted. Additionally, in a previous project, a plot of municipal rangeland close to the Burunoba village have been planted with Atriplex canescens. This operation aimed to launch restoration activities in the surrounding area, while providing green forage to local herds in drought period. This planted area not only bring biodiversity to degraded lands, but also avoid potential conflicts between shepherds and farmers for grazing in private land.

Agroforestry practices implemented

In these fragile conditions, the improvement of degraded rangelands, by the establishment of *Atriplex canescens,* has demonstrated multiple benefits:

The shrubs are extremely drought- and salt-tolerant. Once established, they form a protective cover that anchors the soil surface, reducing wind erosion. Through leaf litter and root biomass, they gradually improve soil organic matter and fertility, creating a more favourable environment for other herbaceous plants to recolonize. In addition to their restoration role, Atriplex shrubs serve as a valuable fodder reserve. Their evergreen leaves are rich in minerals and maintain palatability during the dry season, when herbaceous forage is scarce. This makes them a strategic feed resource for local herds, especially sheep and goats.

Replicability in a similar context

The improved rangeland example from Burunoba has strong potential for replication across the Konya steppe, where rangelands face similar constraints such as low rainfall, calcareous soils, and high wind-erosion risk. The conditions that enable Atriplex to perform well in Burunoba are common throughout Central Anatolia. Other Atriplex species, such as A. halimus, could also be successfully established on the Central Anatolian Plateau, as they respond well to these same challenges.

GLOSSARY

Alley cropping – The planting of trees or shrubs in two or more sets of single or multiple rows with agronomic, horticultural, or forage crops cultivated in the alleys between the rows of woody plants.

Auxiliary species – In agriculture, the term auxiliary species (sometimes called beneficial species) refers to animals, particularly insects and birds, that help farmers by naturally regulating pest populations or contributing to pollination and soil health.

Coppice – Cut back (a tree or shrub) to ground level periodically to stimulate growth. These days, coppicing is primarily a way of improving the health and biodiversity of a woodland area. Coppicing also ensures a regular source of firewood and timber for fences, benches, stiles and stakes for hedge laying.

Hydraulic lift – is a process where deep roots pull up water from wet soil layers and release it into the dry upper soil layers, making water available to shallow roots and nearby plants.

Mycorrhizal fungi, mycorrhizas – Mycorrhizas are beneficial fungi growing in association with plant roots, and exist by taking sugars from plants in exchange for moisture and nutrients gathered from the soil by the fungal strands. The mycorrhizas greatly increase the absorptive area of a plant, acting as extensions to the root system.

Nitrogen fixation – is the process of converting atmospheric nitrogen gas (N_2), which plants cannot use, into ammonia (NH_3) or related compounds that plants can absorb and use for growth. Nitrogen fixation turns unusable N_2 into plant available forms like NH_3, NH_4^+ (ammonium), or NO_3^- (nitrate) after further transformations.

Nutrient leaching – Process of losing water-soluble plant nutrients from the soil, due to rain and irrigation. In high input systems nutrient leaching can lead to soil and water pollution.

Pollard – A traditional method of pruning where the upper branches of a tree are cut back regularly to promote a dense head of foliage and branches.

Shelterbelt – A shelterbelt (windbreak) is a planting usually made up of one or more rows of trees and/or shrubs planted in such a manner as to provide shelter from the wind and to protect soil from erosion. They are commonly planted in hedgerows around the edges of fields on farms.

Symbiotic association, symbiosis - Symbiosis can be defined as any kind of relationship or interaction between two dissimilar organisms, each of which may receive benefits from its partner.

Wood pasture – Landscapes in which livestock grazing co-occurs with scattered trees and shrubs.

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Recommended reading on agroforestry

- TransforMed technical brochure about plant species for semi-arid cold continental drylands (to be issued in 2026)
- *“Tarımsal Ormancılık (Agroforestry)”*, Dr. Ibrahim Turna, Gece Kitapliği, 2023
- *“Face à l’aridité, la puissance de l’arbre”*, Geneviève Michon, IRD Éditions, 2025

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Notes

Notes

Fig orchard with intercropped vegetables: alliums and fennel (Tunisia)

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