DRYLAND AGROFORESTRY: CASE STUDIES FROM THE MAGHREB REGION

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) and real-life examples in the semi-arid Mediterranean, specifically in the Maghreb region. 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 application of agroforestry practices in the arid to semi-arid Mediterranean region, particularly in the Maghreb area.

About the context

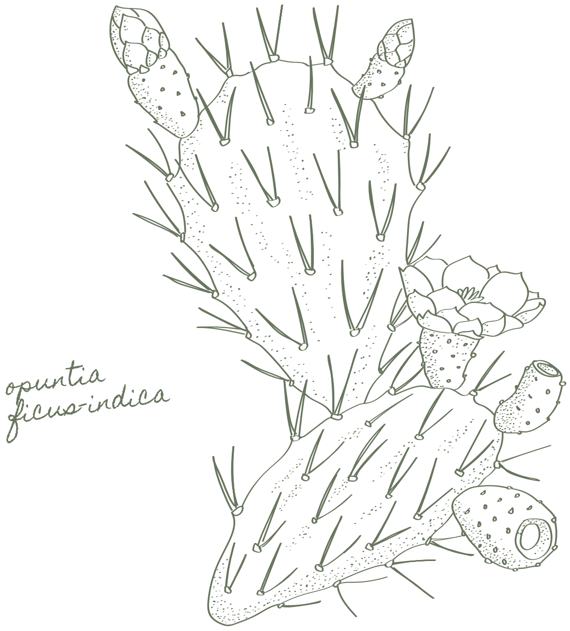
Precipitation in the arid regions of the Maghreb is rare, with several months passing without a single rainfall event. When it does rain, the events are often intense and violent. Maghreb areas also experience strong sunlight throughout the year, high temperatures during the dry season, as well as frequent and often powerful winds.

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

Today, Mediterranean agricultural systems also face common threats, which are aggravated 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 rainfed agriculture, oasis systems, 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 the oasis in North Africa, or 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]

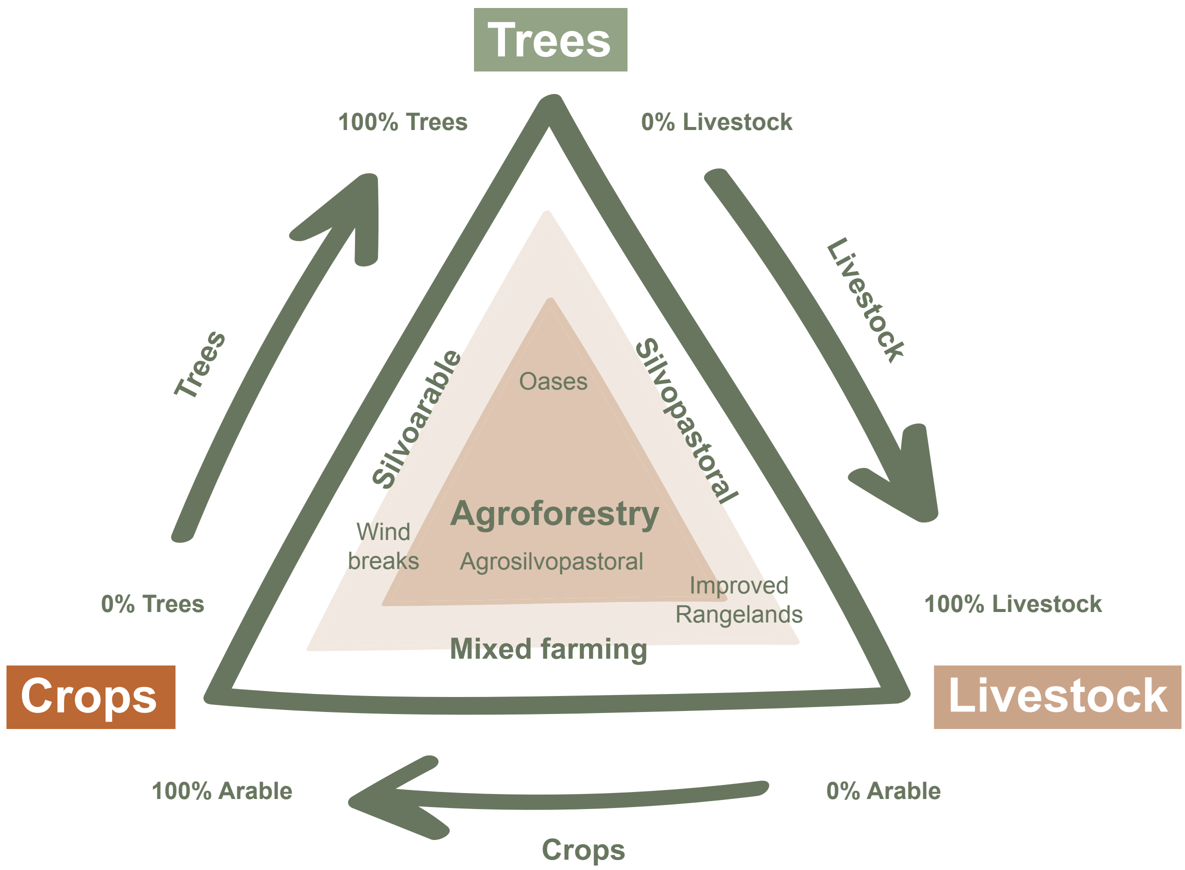
- The intentional coexistence of trees and crops and/or livestock, in space and/or time;
- The presence of significant ecological and economic interactions between trees and crops, and/or livestock.

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 [4,5] 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 [6,7,8]. 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)

Oases

Traditional oases are complex arid and semi-arid agroecosystems based on a three-layer vertical structure: tree floor (palm), arboreal floor (olive, almonds or fruits), shrubs (pomegranates) and herbaceous floor (vegetables, aromatics and forage). Additionally, oases integrate livestock for manure and workforce [9].

Examples
North African Oases (Morocco, Tunisia, Algeria, Egypt), such as Gafsa oasis in Tunisia, the Ksours oasis of Figuig in Morocco.

Multistrata vegetation showcasing diversified production and agricultural management in an oasis (Morocco).

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 [10].

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 [11].

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

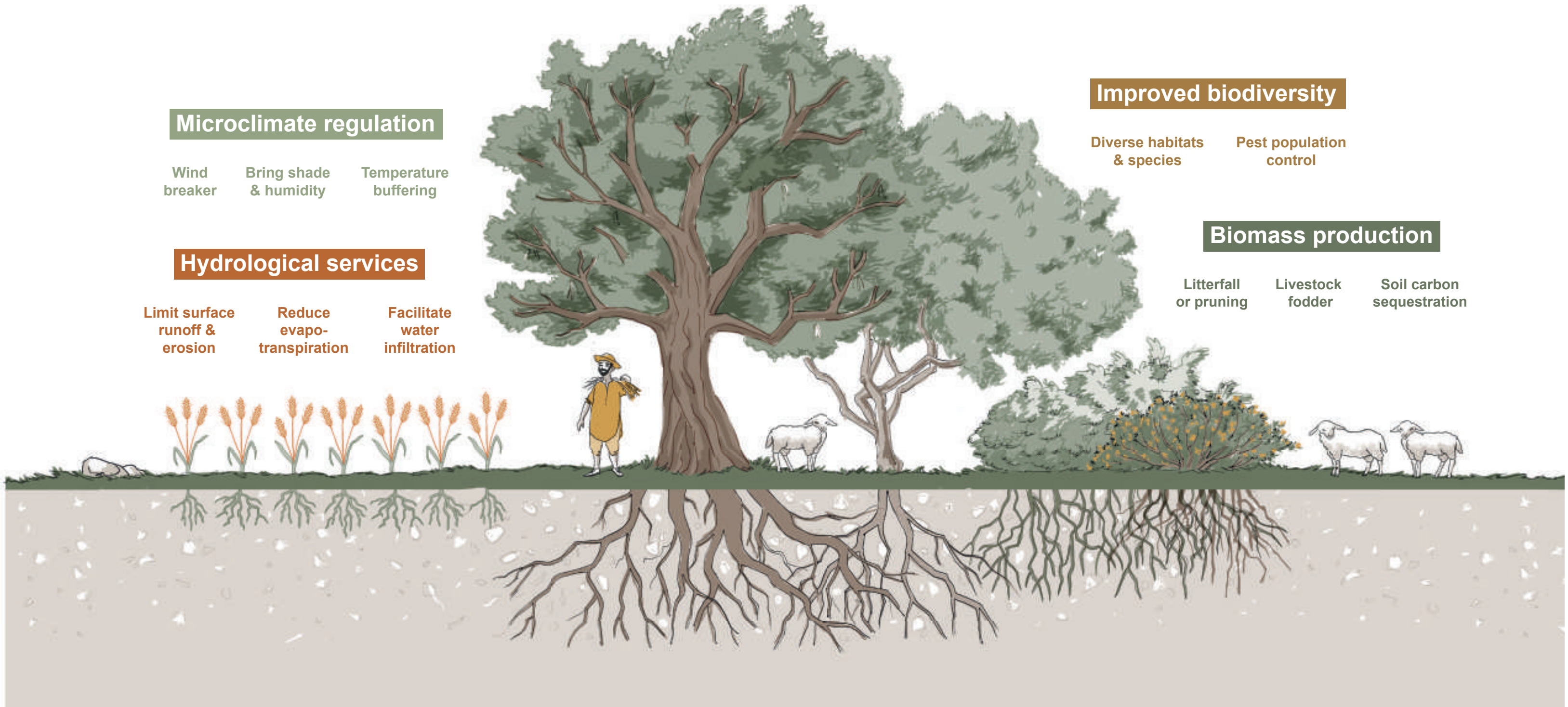


Figure 1: The integration of trees and shrubs into farming systems delivers ecosystem regulation services and additional resources.

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.

The TransforMed technical brochure *"Trees and shrubs for Mediterranean dryland agroforestry - Species guide"* illustrates and describes several nitrogen-fixing plants adapted for dryland agriculture.

Light management

The spacing and orientation of plantings are critical for optimizing sunlight distribution among species. In arid and semi-arid Mediterranean climates, competition for light is generally less intense than in temperate zones. In fact, in many cases, shade becomes beneficial: taller plants can protect underneath crops from excessive heat and help regulate humidity and temperature.

Nonetheless, careful species and variety selection is essential. Shade-tolerant crops should be prioritized for lower strata, ensuring that each plant receives light according to its specific needs.

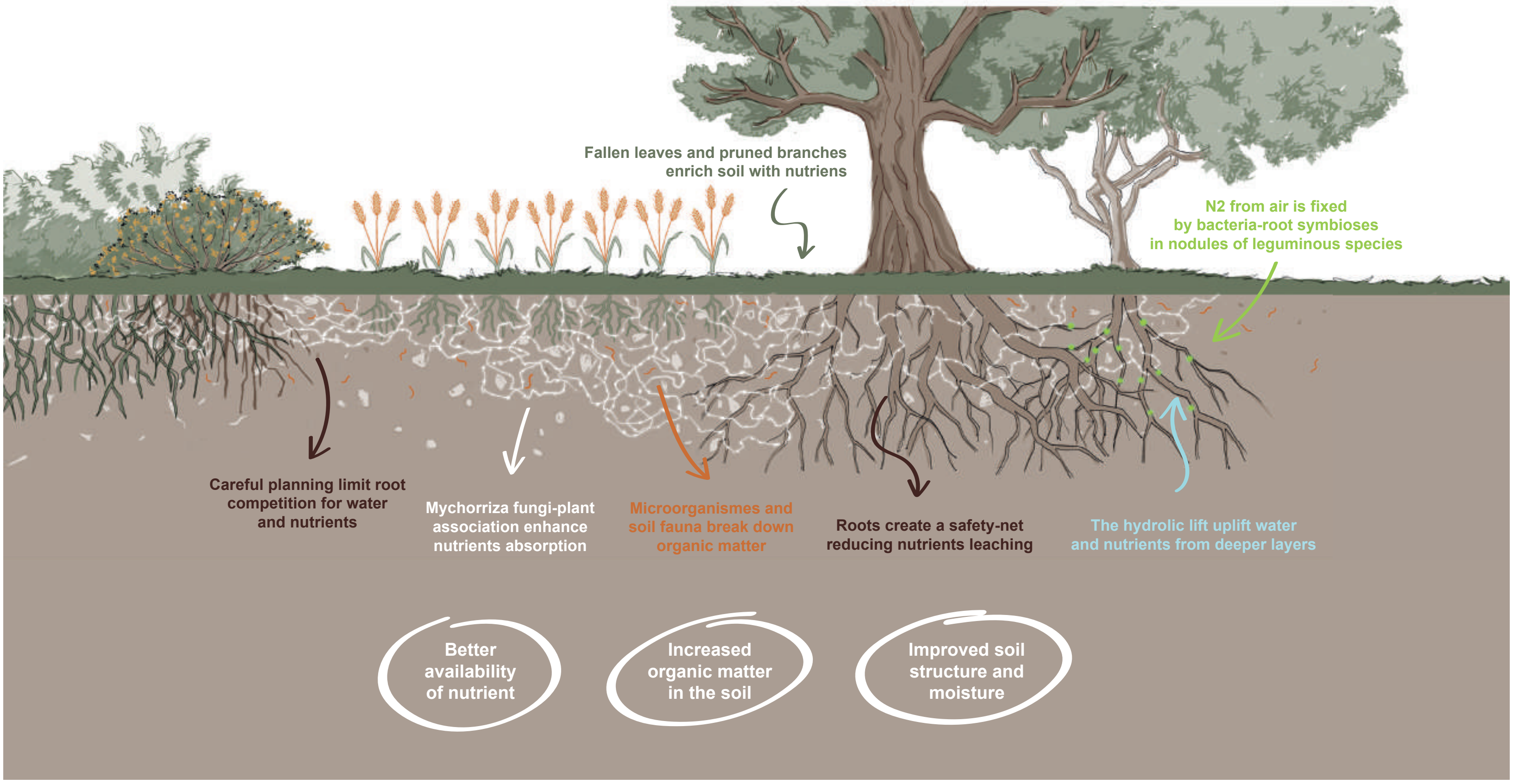


Figure 2: Plant-soil dynamics in AFS.

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 (rare cases in the northern regions of Maghreb).

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.

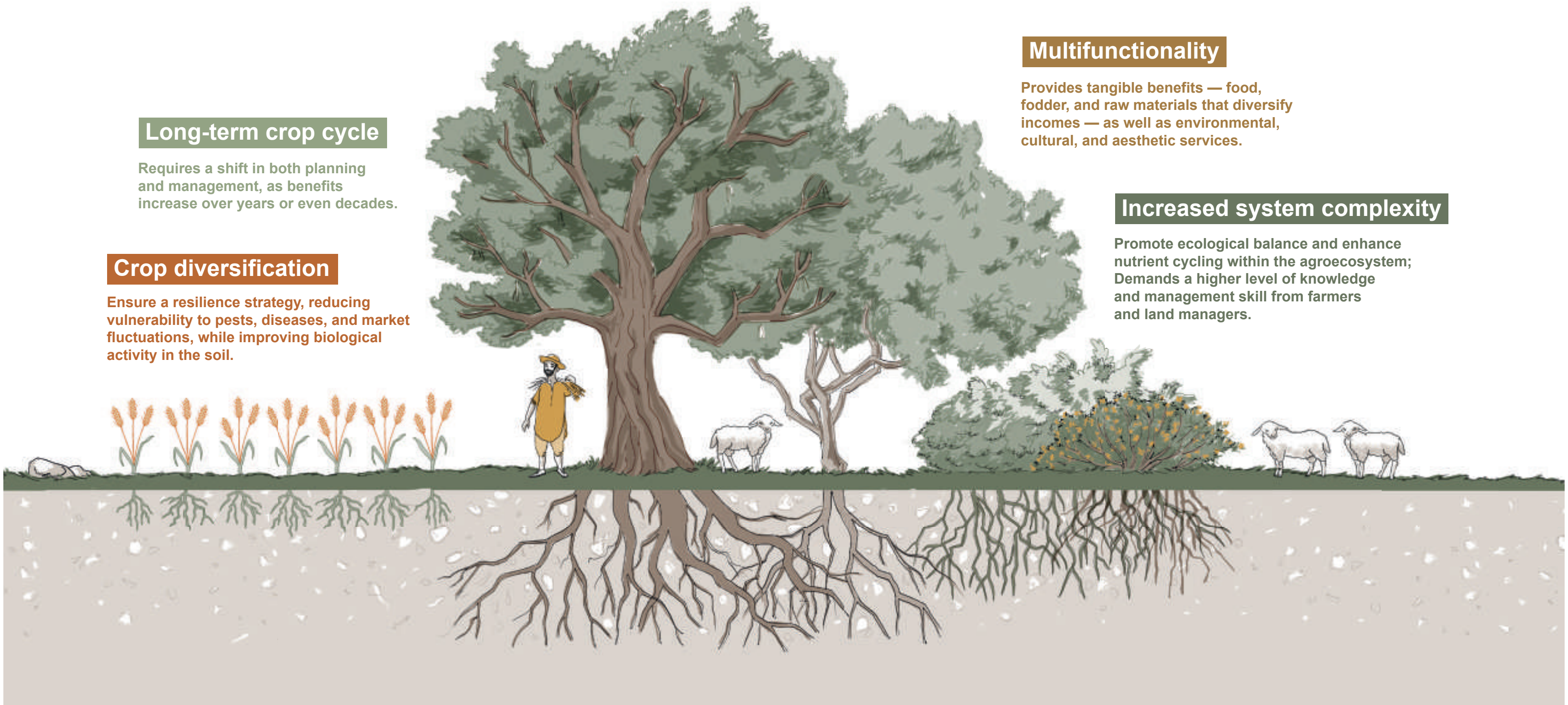


Figure 3: Agroforestry adoption delivers lasting economic, environmental and social benefits.

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 (e.g., carob). 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.

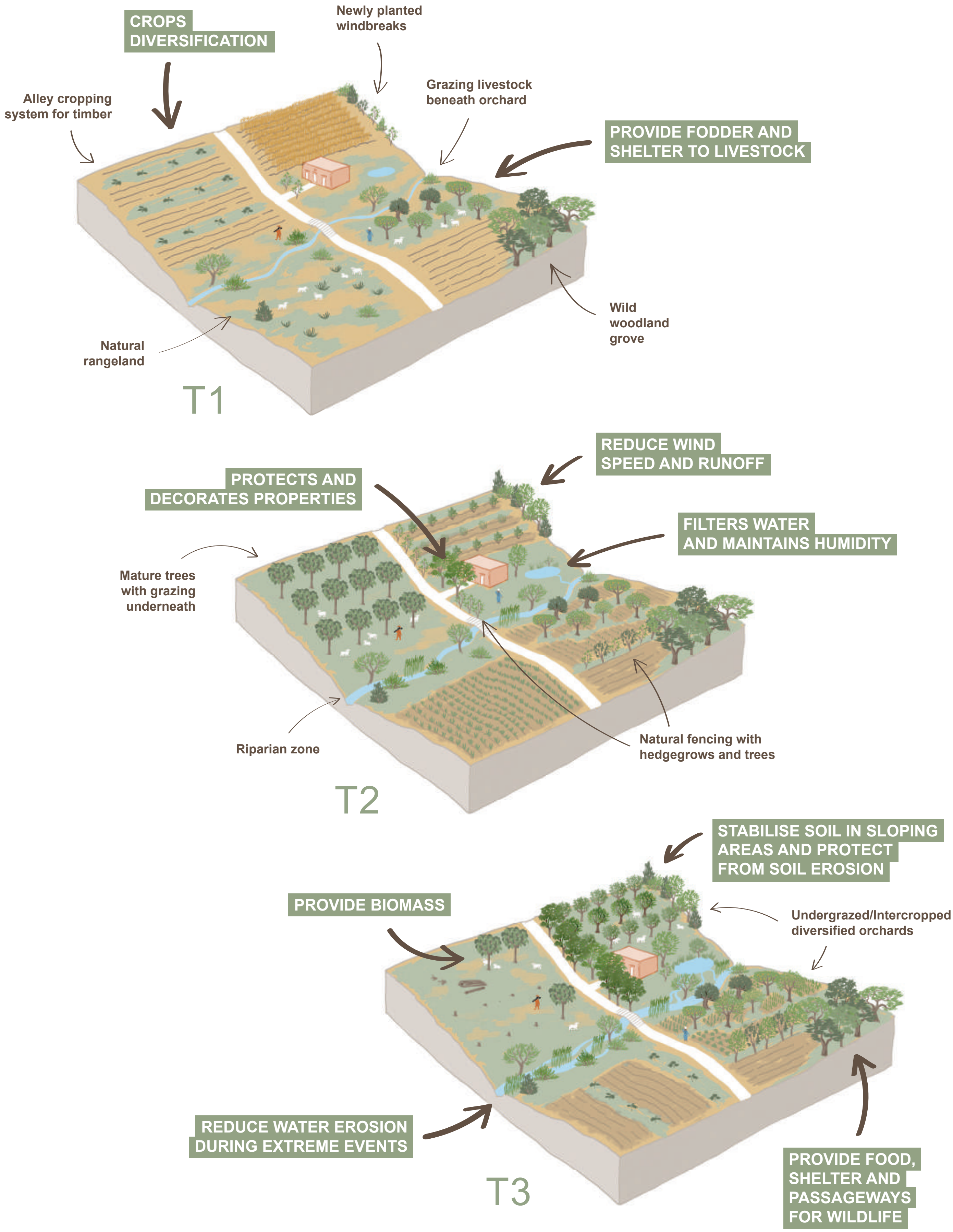


Figure 4: Evolution over time and space of diverse agroforestry systems at the landscape level. As time (T) passes (from T1 to T3), the landscape is transformed and the role of trees also evolves, reshaping the territory and its interactions with other components of the system (livestock, crops, habitat,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

Examples of agroforestry systems across the Maghreb

Chahda
Zaghouan, Tunisia

Type of agroforestry system

Silvopastoral system

Site description

The Chahda site is situated in the semi-arid northern region of Tunisia, within the Zaghouan governorate, and extends across roughly 1,500 hectares. This landscape is characterized by its uneven topography, marked by slopes and gullies that are highly susceptible to erosion, which makes certain areas unsuitable for mechanical cultivation. The region receives an average annual rainfall of between 350 and 400 millimeters. As state-owned land managed by the Direction Générale des Forêts (DGF) under the Ministry of Agriculture, the site is made accessible to the local community, which can utilize it for controlled grazing under nominal rental agreements.

Chahda functions as a silvopastoral restoration site that blends trees, shrubs, herbaceous vegetation with managed livestock grazing. In addition, the site serves as a pilot platform dedicated to training and the demonstration of best practices in silvopastoral systems. Several stakeholders, including institutions and farmers' associations such as the Groupement de Développement Agricole (GDA), are collaboratively involved in designing and implementing innovative solutions; driven by a participatory, bottom-up process.

Agroforestry practices implemented

- **Integration of trees, shrubs, herbaceous plants, and livestock grazing:** the site operates as a silvopastoral restoration area combining plant and animal components.
- **Afforestation with native species:** planting of locally adapted trees and shrubs, especially on slopes and shallow soils.
- **Sulla reseeding:** use of the native leguminous crop Sulla *(Hedysarum coronarium)* on deeper soils to enhance pasture productivity and soil fertility.
- **Regenerative grazing:** managed livestock grazing designed to improve pasture health and encourage regeneration.
- **Agroforestry system setup:** the platform is dedicated to demonstrating Mediterranean AFS, blending ecological restoration with livestock integration.

Replicability in a similar context

The interventions in the Chahda site are specifically tailored for semi-arid zones with fragile soils and issues such as erosion and the need for sustainable integration of trees and livestock. The emphasis on knowledge sharing and collaborative approaches, which unites a variety of local stakeholders and institutional partners, aims to foster the adoption of sustainable silvopastoral practices, thus maximising positive environmental and community impacts across similar regions.

Dar Al Caroube, Khemisset, Morocco

Type of agroforestry system

Silvoarable system,
carob value chain

Site description

Dar Al Caroub is situated in the rural commune of Ait Siberne, located within the Province of Khemisset in Morocco. The site covers approximately 320 hectares, the majority of which is dedicated to carob tree cultivation, complemented by smaller areas planted with argan and olive trees. The carob plantation is supported by an on-site nursery capable of producing up to 80,000 saplings per year, as well as certified grafted plants for selling. The site has five irrigation basins, and storage hangars ensuring water availability for saplings and young trees.

The carob tree *(Ceratonia siliqua)* is well suited to dry, semi-arid conditions due to its low water requirements and drought tolerance, making it an excellent choice for the Khemisset region. Its economic potential is increasing as demand grows from food and processing industries, which value carob for its health benefits and use as a natural cocoa substitute. Recognizing this opportunity, Dar Al Caroub opened a modern processing factory in 2017 that plays a key role in adding value to local production. The facility employs a core permanent workforce alongside seasonal workers and processes around 1,000 tons annually, mostly for export markets. It also features exhibition rooms showcasing products such as pulp, seeds, flour, carob tea, and coffee, and hosts workshops and training sessions to support knowledge sharing and farmer development. This integrated approach boosts rural incomes, supports job creation, and helps build a sustainable carob value chain in the region.

Agroforestry practices implemented

- **Locally adapted species:** large-scale plantation of carob trees suitable for land restoration in semi-arid and degraded contexts.
- **Testing Intercropping:** plantation of 4 hectares of aromatic and medicinal plants in between the rows of carob trees.
- **Nursery establishment for grafted/certified plants:** advanced propagation supporting the extension of agroforestry outside the original site.
- **Organic farming and low-tillage methods:** practices such as surface tilling, mulching with pruned leaves, and minimizing chemical inputs, help improve soil structure and health. Certified Organic since 2020.
- **Value-chain integration:** the site incorporates not only tree planting, but also processing and marketing, improving land productivity, and enhancing farmers' incomes.

Replicability in a similar context

The choice of the drought-adapted carob tree demonstrates how native and/or drought-resistant species can be leveraged for large-scale restoration efforts with minimal irrigation needs. In addition, the integrated approach, combining nursery production, plantation management and processing, ensures a sustainable value chain that fosters local economic development.

Laassaba,
Essaouira, Morocco

Type of agroforestry system

Silvoarable system,
argan value chain

Site description

The Laassaba site is located in the west-central arid region of Morocco, within the municipality of Korimate in Essaouira province. Spanning a total of 53 hectares, the Laassaba hilly landscape lies on limestone bedrock. This geological setting supports a substantial groundwater aquifer, which serves as a key irrigation resource for the area. The climate here is typically semi-arid, which means that it is characterized by low and irregular rainfall ranging from 100 to 300 millimetres annually. This reflects the region's irregular and scarce precipitation patterns. The Laassaba site, which is managed as communal land under the Ministry of Interior, has been formally granted for community agroforestry use.

The Laassaba site is dedicated to tackling land degradation and desertification by planting native, drought-tolerant species such as argan *(Sideroxylon spinosum)* and caper *(Capparis spinosa)*. This initiative is driven by a broad coalition of stakeholders, including more than 170 local community members who are organized through established groups such as Coopérative Caroubi Arg and the Provincial Association of Right Holders (APAD). Central to the project is an inclusive governance model operated through the local cooperative, which places special emphasis on empowering rural women and ensuring wide community participation in decision-making and project activities.

Agroforestry practices implemented

- **Revegetation with certified argan and caper seedlings:** restoration of communal lands through planting of native and drought-tolerant tree/shrub species.
- **Bio-compost application:** use of organic compost to improve soil fertility.
- **Climate-resilient water management techniques:** implementation of contour planting and stone mulching to enhance moisture retention and reduce erosion.
- **Multi-phase plantation model:** systematic, scheduled planting and maintenance to improve survival rates and ecosystem restoration.

Replicability in a similar context

The use of native and climate-resilient species, combined with accessible restoration techniques such as bio-composting, contour planting, and structured maintenance, are practices largely responsible for the success of the plantation and could be a source of inspiration for regions facing similar climatic conditions.

Furthermore, Laassaba's model of inclusive, cooperative governance contributes to social cohesion and sustainable community management; aspects that are critical for the planning of local sustainable strategies.

The agroecological farm, Siliana Governorate, Tunisia

Type of agroforestry system

Silvoarable system,
agroecology

Site description

The agroecological transition farm is located in the northern part of the Siliana governorate. It lies within the upper semi-arid bioclimatic zone. The landscape is characterized by undulating hills and shallow valleys, with fragile soils highly susceptible to erosion. On steep slopes, conventional agricultural practices have historically accelerated soil degradation and nutrient depletion. The region receives an average of 450 mm of annual precipitation, with significant inter-annual variability that directly affects both agricultural and pastoral activities.

It is a family farm managed across generations. In recent years, the family has initiated a significant transformation by adopting an agroecological transition strategy. This approach aims to strengthen resilience to climate change, enhance resource management, and ensure the sustainability of agricultural production. The farm also serves as a demonstration and learning platform for the local community, particularly the members of the Agricultural Development Group, which brings together farmers from the surrounding area. Regular training sessions, workshops, and pilot initiatives are organized on site to disseminate sustainable agricultural practices and land restoration techniques.

Agroforestry practices implemented

- **Plantation and diversified orchards:** orchards mainly combine olive, almond, and fig trees. Complementary species such as carob and acacia have been also introduced. These trees play a key role in soil stabilization and in preserving long-term fertility.
- **Intercropping between trees:** to optimize land use and diversify production, several intercrops are cultivated between tree rows:
  - **Forage mixtures:** composed of carefully selected grasses and legumes, these mixes are valued for their high nutritional content, fast growth, and high productivity. They also help control pests and diseases while improving soil fertility and structure.
  - **Sulla *(Hedysarum coronarium)*:** this biannual, honey-producing plant with high nutritional value enhances soil fertility through its ability to fix atmospheric nitrogen, while also providing quality forage.
  - **Annual legumes (vetch, faba bean, etc.):** these crops increase soil fertility, stimulate tree production, and ensure better ground cover, thus reducing erosion.
  - **Aromatic and medicinal plants (lavender, etc.):** these species provide significant ecological and economic benefits. Highly attractive to pollinators, they strengthen biodiversity and open opportunities for local value chains in medicinal and honey-producing plants.
- **Composting and organic waste recovery:** farm residues (manure, pruned branches, twigs, and other organic waste) are processed through composting. This practice produces high-quality organic amendments that improve soil fertility and structure, while reducing the loss of organic matter.
- **Establishment of a nursery:** the farm has also set up a nursery dedicated to the propagation of young carob seedlings as well as various aromatic and medicinal plants. This initiative ensures the availability of locally adapted plants, promotes their dissemination among farmers in the region, and strengthens the resilience of production systems.

Replicability in a similar context

The agroecological farm is the result of a transition process built on participatory research, based on co-design and the sharing of experiences among the scientific community, associations, and local stakeholders. This collaborative dynamic enables it to serve as a reference model for neighboring areas facing similar pedoclimatic conditions and challenges.

Atriplex platform, UM6P, Benguerir, Morocco

Type of agroforestry system

Silvoarable system,
soil regeneration,
fertility management

Site description

The Atriplex platform is located at the Agricultural Innovation and Technology Transfer Center, at Mohammed VI Polytechnic University (UM6P) in Benguerir, Morocco. This region is characterized by an arid climate with an average annual precipitation of 190 mm and an average annual temperature of 19.5°C. The platform was established in January 2020 and spans 5.12 hectares, of which 2.2 hectares were planted under the TransforMed Project in 2024. The system is based on *Atriplex nummularia,* a drought- and salinity-tolerant shrub, with an alley-cropping design. The site incorporates innovative soil management practices, including the application of sewage sludge compost, with the goal of enhancing soil fertility, improving water retention, and reducing post-planting reliance on irrigation. This makes the platform particularly relevant in the context of Morocco's increasing drought stress and soil salinisation.

Agroforestry practices implemented

- **Alley cropping with *Atriplex nummularia* and cereals and legumes sowed using no-tillage seeder:** combining perennial shrubs with seasonal crops to maximize land use efficiency.
- **Alley cropping with *Atriplex nummularia* and cactus:** integrating drought- and salinity-tolerant species to enhance resilience, provide fodder resources, and improve soil conservation.
- **Soil fertility management with compost:** use of sewage sludge compost to improve soil health, organic matter content, and water retention capacity.
- **Water-use efficiency strategies:** designing the system to lower irrigation requirements after establishment and to enhance resilience under drought conditions.
- **Multipurpose shrub integration:** Atriplex provides fodder resources while contributing to soil stabilisation and salinity tolerance.
- **Demonstrative function:** the platform is established as a pilot site for knowledge transfer and demonstration of agroforestry innovations.

Replicability in a similar context

The interventions tested in this platform are highly relevant for semi-arid and arid regions facing the combined challenges of water scarcity, soil salinity, and land degradation. The integration of drought- and salt-tolerant shrubs with other crops, alongside soil fertility restoration practices, offers a scalable model to enhance both productivity and resilience. The approach can be replicated across similar agronomic and climatic areas in the Mediterranean, particularly where sustainable land management and reduced irrigation dependency are priorities.

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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Further information on agroforestry in Maghreb

Readings

- TransforMed technical brochure n°3 – *“Trees and shrubs for Mediterranean dryland agroforestry - Species guide”* (to be issued in January 2026)
- *“Guide sur les techniques de reproduction et de multiplication du caroubier en Tunisie”*, Association les Amis de Capte Tunisie (LACT) & Institut de Recherches en Génie Rural, Eaux, et Forêts (INRGREF), 2023
- *“Face à l’aridité, la puissance de l’arbre”*, Geneviève Michon, IRD Éditions, 2025

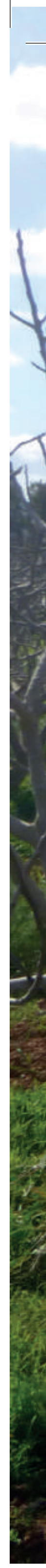

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Fig orchard with intercropped vegetables: alliums and fennel (Tunisia)

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