ResAlliance

Building Resilient Landscapes in the Mediterranean: Knowledge for Agriculture and Forestry

Putting Knowledge into Action: Practical Solutions and Demonstrations

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Introduction

There are very few areas in the world where landscapes have been so profoundly shaped by traditional land management practices, resulting in a variety of cultural landscapes that support a rich diversity of species and ecosystems. Over centuries, civilisations and communities have transformed Mediterranean landscapes according to social changes and climate variability, keeping them resilient. However, the speed and intensity of these changes in recent decades are unprecedented. The Mediterranean basin is one of the world regions experiencing the fastest warming and the greatest decrease in rainfall, which aggravates climate-related disturbances. In the last decades, the population has become increasingly urban, particularly in North African and Middle Eastern countries, while cropland and rangeland have decreased, particularly in European mountain areas.

As in the past, Mediterranean communities must adapt their increasingly vulnerable landscapes, yet today, the urgency is greater than ever. These landscapes and associated cultural land management practices need to be able to withstand, recover from and transform in response to climate-related stresses and shocks, while taking into account climatic and socio-political uncertainties. Building resilience into these systems is no longer optional; it is essential.

Although dozens land management practices, technologies and governance and financial schemes exist to maintain or enhance farm and forests resilient, many of them are not broadly disseminated. Reasons are multiple. In many cases, the creators of these practices do not have the mandate to internationally disseminate them, or ancestral practices may be disregarded by the society. Added to this are language barriers. The ResAlliance project has helped to remove these barriers through a consortium of 16 partners that has explored the needs of Mediterranean agricultural and forestry stakeholders in order to tackle the disruptions caused by climate change: fires, drought, desertification, floods, pests and diseases. For these professionals, ResAlliance has identified 120 practices from different countries that are ready to be implemented. In addition to face-to-face knowledge transfer activities, a massive open online course (MOOC), a series of recommendations for Mediterranean countries and regions to facilitate the establishment of these practices, and a virtual community of more than 2,000 members, ResAlliance leaves for posterity this collection of 120 fact sheets describing these practices in detail.

Maintaining or enhancing landscape resilience is a collective responsibility shared by a diverse range of stakeholders. Some actions can be carried out independently by individual farmers, herders, and forest managers on their own land. Others require coordinated efforts across multiple properties, often facilitated by associations such as farmers' groups or forest owners' organisations. In certain cases, the involvement of civil society organisations is essential. However, to ensure the successful implementation and full effectiveness of these actions - whether managerial, technological, financial or governance-related - new or adapted policy instruments may be necessary, together with medium- and long-term action plans.

On behalf of all the members of the ResAlliance consortium, I hope that you will find in this collection inspiring practices so that our fields, pastures, scrublands and forests continue to exist despite the climatic pressures they face, continue to sustain the biodiversity that has flourished in them, and that populations can continue to benefit from the products and services they offer us.

'ResAlliance is one of the few EU-funded projects that brings together farming, livestock and forestry sectors, because the resilience of our landscapes does not stop at the edge of the forest or at the margin of our fields.'

What was the ResAlliance project?

Climate change is increasing the frequency and intensity of extreme weather events. It is believed that **at least 85% of the world population has experienced extreme weather events worsened by climate change**, with particularly high damages and losses in agriculture and forestry.

In this context, **the Mediterranean basin is particularly vulnerable to climate change:** this region is warming 20% faster than the global average. Still, solutions exists and today there is a growing consensus among academics, experts and practitioners that these hazards must be addressed proactively through building resilience at landscape level. However, today the application of solutions to improve landscape resilience is still slow and faces many barriers.

Against this background, the **ResAlliance project** (complete name "Landscape resilience knowledge alliance for agriculture and forestry in the Mediterranean basin") was a thematic network project funded by the Horizon Europe Programme of the European Union, which **aimed to improve information and knowledge flow and increase the capacity of foresters and farmers, providing tools necessary to implement innovative solutions on landscape resilience**.

Focusing on Mediterranean countries, **ResAlliance gathered and assessed knowledge, gaps, barriers, and good practices to achieve resilient landscapes**, with particular emphasis on measures against the hazards of climate change.

ResAlliance was made of **16 partners from different Mediterranean countries.** Among them, there were universities, research centres, businesses and much more, drawing from their experiences and different expertise to promote innovation in landscape resilience.

Promoted by EFI

In partnership with ETIFOR, European University Cyprus, CER!DES, CIFOR, CIHEAM, CTFC, D.R.E.A.M. Italia, ELGO-DIMITRA, EURIAE, Forestas Sardegna Foreste, Instituto Superior de Agronomia, IUCN, IRTA, PAU Costa Foundation

Collecting knowledge: ResAlliance methodology

This **collection of practices and case studies was based on different information sources** approached during the ResAlliance project: the expertise of project partners; previous projects and links to the forest, agriculture and agroforestry sectors; available raw knowledge in research and practice and the information obtained from the project LandLabs (Figure 1).



Figure 1. Distinct sources of information for the collection of best practices.

LandLabs were on-the-field laboratories focused on landscape resilience, located in **five Mediterranean areas** highly exposed to climate change hazards. The LandLabs operated on a **regional scale** to address the major impacts and challenges faced by farmers and foresters in each area.

To achieve this, the LandLabs carried out **various activities** such as **events, workshops, field trips,** and demonstration **showrooms.** These activities helped farmers and foresters identify and adapt their **most relevant need challenges** and their **most suitable solutions** for their specific regions (Figure 2).

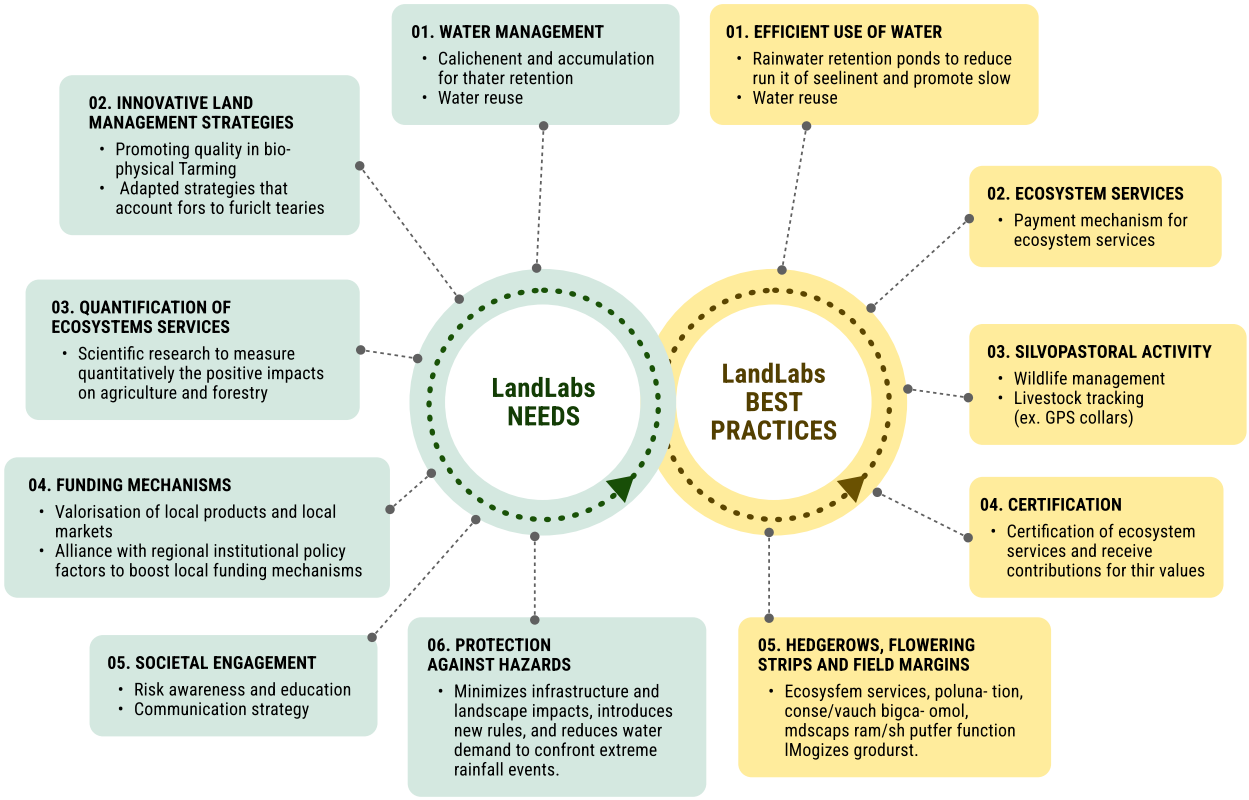


Figure 2. List of needs and best practices resulting from LandLabs activities. Authorship: Pau Costa Foundation.

The LandLabs were located in five Mediterranean regions highly **exposed to climate hazards: Sardinia** (Italy), **Catalonia** (Spain), **Peloponnese** (Greece), **Cyprus,** and **Região Norte** (Portugal). In addition, two focal points—**Lebanon** and **Tunisia** — also participated by sharing knowledge and expertise on how to address climate hazards in the Mediterranean region.

Chapter 1

Individual Practices

Landscape resilience is built with broad-scale measures but also through individual small-scale decisions. Agriculture and forest managers across the Mediterranean region can build and implement innovative solutions that show how actions at this level can have significant ecological and social impacts.

Individual practices have typically the advantage of being applied by those who understand the territory and its dynamics. These are responses from local professionals to climatic and socioeconomic threats like wildfires, soil degradation, water shortages or loss of biodiversity. Such innovations, by adapting measures to environments and cultural settings, demonstrate the strength of individual commitment in safeguarding both livelihoods and the ecosystem.

Examples throughout this chapter illustrate the variety of these contributions. Cypriot vineyards are strategically located as natural firebreaks, protecting forest and communities from wildfires while producing excellent agricultural products. In Tunisia, fig and carob trees are managed as natural firebreaks and tools to combat soil degradation. In Spain, examples like forest horses demonstrate how individual initiatives can generate alternative species to manage shrub encroachment and lower wildfires occurrence and impacts.

These practices share the potential to transform individual responsibility into collective resilience. Such initiatives show that individual landowners are valuable partners in building resilient landscapes by combining production with protection, tradition with innovation, and short-term need with long-term sustainability.

Firebreak vineyards: natural solutions to retard the spread of forest fires

Tsiakkas Winery as a Case Study: The Role of Surrounding Vineyards in Containing a Mega Fire.



Figure 1. Vineyards in Agros.
Author: Tsiakkas Winery | © Educational use, non-commercial.



Figure 2. Tsiakkas Winery two years after the Saittas Fire in 2007. Winery, house and pinewood trees remained intact.
Author: Tsiakkas Winery | © Educational use, non-commercial.

/// Context ///

Winemaking in Cyprus dates back to ancient times, as indigenous grape varieties and traditional winemaking techniques are easy to trace. Cyprus is home to unique grape varieties such as Xynisteri (used to make white wine) and Mavro (used to make red wine), as well as Commandaria, a famous sweet dessert wine. The island of Cyprus has many examples of vineyards being used as firebreaks. During the mega fire in the Saittas area in 2007, the Tsiakkas winery was completely saved by the fact that the strategically placed vineyards around the winery acted as a pure firebreak. The fire burned the entire surrounding pine forest, but the old pine trees inside the winery are still thriving today. Tsiakkas' example was noted by the services, and since then vineyards have been considered an ally of the operational fire-fighting teams, who take them seriously in both prevention and fire-fighting planning. The case for using vines as a fire protection measure is made even more compelling by photographs taken the day after the fire, where the black is interrupted by green vineyards unaffected by the fire. Successful use of this tool depends on two main factors: good vineyard management and the characteristics of a green vineyard. The sap retained by these plants, the humidity they generate, the planting structures and the islands in which they are installed are all factors in a multi-level useful tool for fire management.

/// Solution for a Resilient Future ///

Benefits of using vineyards as firebreaks:

- Levels of moisture – Natural resistance to fire: vine plants have deep rooting system enabling deeper access to soil moisture (as well as soil stabilization reducing soil erosion). Their leaf structure is characterized by high moisture levels when green, while the coverage they provide the soil with preserves the ground moisture.
- Effective fuel reduction: the management of the land (pruning, watering, removal of debris) is very important in preventing a fire as well as breaking it's spreading.
- Structural and spatial benefits: the way planting is structured in isles, create physical barriers, fire is retarded by the moisture of the slow-burning leaves, reducing spreading speed, helping fire services in dynamics as well as time management, maintenance and accessibility.
- Economic and environmental benefits: vineyards as fire breaks provide a win-win scenario both for economic / business orientation as well as environment. It is a well-known ancient practice – nature based solution, where vineyards provide a multilevel frame of environmental economics offering a lot of secondary products : preventing soil erosion, wine making, wine to preserve other foods, sweets from vines juices, use the leaves in cooking as well as sell the grapes as fruit.

More to the above, vineyards also provide aesthetic to the land mosaic (Figure 1) and add to the community value providing not only to economy, but to fire safety as well, offering a sense of security. Having mentioned all the above, it is clear that vineyard planting is one of the many tools that can be included in synergy and combination of other on this battle to mitigate the results of weather phenomena. Integration into other strategies (drystone walling, controlled grazing, prescribed burning

etc), strategic management of areas can be really helpful. Also, vines seem to adopt perfectly different kind of terrains as well as high temperatures, a really important factor into resilience efforts.

Implementation Considerations:

In order to use this tool in the most beneficial way and maximize the effectiveness of vineyards as firebreaks, we must consider Strategic Areas to plant vine-zones (including other fire-resistant landscaping and infrastructure), to ensure their proper maintenance and management and create an effective set of incentives to help private owners invest more in vineyards as firebreaks. One of the big challenges concerns the level of incentives and how they can be made really attractive to have an effect. The discussion mainly concerns the incentives of small landowners and whether the incentives that will be granted will really be attractive and serve the sustainability of the venture. Specifications and recommendations should be made for financing professional networks for this purpose, or in the context of social work.



Figure 3. Vineyards designed with dry stone walls, working as fire breaks and soil retainers.
Author: Tsiakkas Winery | © Educational use, non-commercial.



Figure 4. Vineyards intact five days after the Paphos Fire (2024).
Author: Haris Nicolaou | © Educational use, non-commercial.

/// Always Moving Forward ///

The planting of vineyards, as a public good for the prevention of forest fires and also as an important tool for soil conservation, is high on the list of priorities of the Cyprus Forestry Department. As a solution for the abandoned areas, a pact of subsidies for the planting of vines for purposes of public interest and benefit, and not necessarily for commercial use, is being considered. In addition, as mentioned in the previous section, within the framework of broader strategies, the specific practice is included in combination with the construction of dry-stone walls, the exploitation mechanisms of abandoned lands and their use by the small wineries in the mountains, which do not invest in quantity but in quality (as smaller plots of land can therefore be excellently used).

The Cyprus Forestry Department is planning training in the near future on fire prevention practices, including the fire retardant properties of vines. In addition, strategic management areas are being developed that include vineyards as firebreaks as well as controlled grazing and prescribed burning.

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ResAlliance

Carob and fig trees as natural firebreaks and tools to combat soil degradation and erosion in Tunisia

Connecting science and business for high-impact investments in Nature-based Solutions.



The carob tree, known for its resilience and robustness, holds significant socioeconomic importance. It helps mitigate the effects of climate change.
Author: @Sondes Fkiri | © CC BY



Participation of the region's rural women farmers in plantation campaigns.
Author: Capte 2016 | © CC BY

/// Context ///

Tunisian forests are particularly vulnerable due to several factors. Firstly, their mountainous locations expose them to a higher risk of fires. Secondly, the presence of dense, resinous vegetation makes them highly flammable, worsening the situation. Ultimately, inadequate forest management and the lack of proper clearing work are major contributors to their vulnerability, as these practices could prevent large-scale and devastating fires.

The frequency, destructiveness, and intensity of fires have increased as a result of anthropogenic activities, accentuated by the effects of climate change, compromising any attempt at natural or artificial forest regeneration. In Tunisia and the Maghreb region, initiatives to plant fig and carob trees are commendable. These trees act as effective natural firebreaks, helping to mitigate the impact of fires. Such initiatives are crucial for protecting our forests and promoting sustainable practices. In addition, these tree species contribute to soil stabilization and water conservation, further enhancing the resilience of the ecosystem. The involvement of local communities in such initiatives is essential to the success of these reforestation efforts, as well as enhancing the economic benefits of these projects by fostering a sense of ownership and responsibility towards the environment.

/// Solution for a Resilient Future ///

The landscape in the mountainous areas of Tunisia is characterized by a mosaic of forests and agricultural land. Given the climate change recorded during the last decade, marked by prolonged periods of drought and spatial disparities in precipitation, these areas have become vulnerable to fires. In August 2023, 4800 hectares of forests have been ravaged by fires, including 1177 hectares in the Melloula region (Jendouba), a 20% decrease compared to the 5900 hectares burnt in the same period in 2022. These fires damage the forest ecosystem and result in the loss of agricultural land for the local population living near these areas. Farmers in the project area often practice monoculture or have uncultivated land with degraded soil prone to erosion. However, associating traditional crops with fruit or forest trees helps improve biodiversity, create a sustainable ecosystem, and fight forest fires.

In Tunisia, as in the entire Mediterranean region, climate change will require farmers to adapt their farming practices; those that are too water-intensive or highly sensitive will become difficult to maintain. As part of preventive actions and firefighting efforts, the objective of the Trans.sénia project ("Sénia" means "Farm" in Tunisian dialect) is to establish model agroforestry plots in the Bizerte region and promote this practice as one of the solutions to the current challenges (drought, fires, etc.). Therefore, the aim is to create carob-fig corridors. Supported by its partners, the association "Les Amis de CAPTE-Tunisie" has committed to restoring a burned plot by installing a hedge of carob and prickly pear trees.

The planting of mixed-use forest tree hedges is not only useful as windbreaks or fences, but also effectively combats erosion and fires. In total, approximately 1100 fruit trees and 2000 forest trees have been planted on the farms involved in this project this season. At each site, a small composting unit is installed, with shredding and fresh manure, to raise awareness among farmers about the importance of recycling organic farm waste,

providing a “concrete illustration” of these benefits. Additionally, a pilot orchard of 7 hectares of carob trees was planted in 2017/2018, and 15 hectares of spineless prickly pears were planted in 2019/2020, aiming to reforest wadis with mixed hedges to limit the impact of water and wind erosion, complementing these agroforestry systems.

Managing fig and carob plantations starts with careful planning. Site preparation includes clearing, ploughing and levelling. Young plants are generally planted during the rainy season to ensure adequate water availability. After planting, regular watering, especially during dry periods, is crucial, with drip irrigation being an effective method. Fig and carob fruits are harvested and post-harvest managed when fully ripe for optimum quality. Biodiversity is promoted by intercropping with other species and maintaining natural vegetation.

Indeed, such a pilot experience contributes to combating the effects of climate change, to the development of solidarity among farmers, and to the improvement of agro-ecosystems, their biodiversity, and resilience in the Bizerte region. It will serve in the future to popularize this practice and its benefits throughout the territory.



Planting fig trees helps combat water and wind erosion and regenerate depleted soils. Additionally, their fire resistance reduces the risk of wildlife spread.
Author: https://pampat.tn/wp-content/uploads/2019/03/La-Figue-de-Barbarie-Les-secrets-dun-fruit-magique-FR.pdf | © CC BY



Carob orchard Les amis de Capte, Lake Bizerte. Tunisia, in 2016.
Author: Capte 2016 | © CC BY

/// Always Moving Forward ///

Nowadays, the carob tree and the prickly pear are considered valuable resources for farmers in Tunisia. Originating from the Mediterranean region, the integration of the carob tree into agroforestry practices will promote the sustainability of agricultural and forest landscapes for the region. Fig and carob trees are good natural firebreaks and play a socioeconomic role dating back to antiquity (income source, animal and human food, agro-food industry, etc). The success rate of the plantations is very high and can reach 90%. Using other semi-forest trees, as pistachio (*Pistacia vera*), could also be recommended.

In Tunisia, several stakeholders are currently developing and valorizing the carob tree and the prickly pear, both in the forestry and agricultural sectors. The goal is their integration into reforestation projects as multipurpose species, particularly to enhance resilience to climate change, especially in response to drought and for fire prevention. To succeed in these reforestation initiatives, it is essential to produce high-quality seedlings, better adapted to the new conditions.

The successful implementation of these agroforestry systems addresses environmental challenges and provides economic benefits to local communities. The diversification of crops enhances food security, while the sale of fig and carob products contributes to household income. As these practices become more widespread, they can serve as models for other regions facing similar challenges, promoting a sustainable and resilient agricultural future.

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Partners: INRGREF – National Institute of Rural engineering research, Water and Forests

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ResAlliance

Forest Horses: forest management and environmental awareness on a local scale

The Forest Horses Association has been working for four years on the management of Mediterranean pine forest stands through silvopasture with equids. The introduction of this herbivore is changing both soil and understory.



Low trees and understory density are comfortable spaces for horses.
Author: Forest Horses Association | © CC by Forest Horses Association



Horses are gregarious animals. They move as a group, conserving their ancient prey role. They create pathways across the pine forest.
Author: Forest Horses Association | © CC by Forest Horses Association

/// Context ///

The Forest Horses Association identified a lack of interest from the local community towards dense Pinus halepensis forests. Ten horses were introduced to act as a key species in this ecosystem. Since horses are nowadays leisure-related animals, there is a lack of experience in forest management with this herbivore. Mediterranean forests are not nutritionally optimum for this big mammal, but they can graze over many different plant species in the understory, which can be positive for smaller mammals such as goats or sheep, as they open paths in dense forests. Additionally, the ecosystem is improving in soil fertility through horse manure.

Forest owners and local residents are reaping the benefits of fire prevention thanks to the grazing activities of these large herbivores. Meanwhile, the association is actively promoting environmental awareness among the community. Also, new habitats such as open spaces, water ponds, and bird nest boxes are being created through volunteer efforts organized by the association.

As a non-profit organization, their activity has always been supported by a volunteering team and other stakeholders who are also interested in forest management, animal welfare, and nature conservation.

Introducing new activities on a typical abandon situation in mediterranean forest can shift synergies around fire risk community awareness and biodiversity losses due to landscape homogeneity, as well as generating experience on equids management as a feasible option.

/// Solution for a Resilient Future ///

The Forest Horses are located in the south of the Penedès wine region, where the orography is hilly, and vineyards are being abandoned from decades ago. In addition to this, extensive grazing of goat and sheep flocks has roughly diminished in this area. These changes have entailed major changes in the territory, leading to increased vegetation load and landscape homogenization with forests dominated by Pinus halepensis, ultimately increasing fire risk.

Mechanical clearing and cutting are rarely being promoted because of the low value of the wood and lack of governance to engage forest owners in the management of their forest plots.

Some years ago the project found a concious forest owner who is also producing organic wine and conserving ancient vineyards in the area (Valldolina). The organization was able to start their activity in a non-managed forest, letting 10 horses in “free-range” regime. The total forest area was divided in four enclosures from 5 to 60 hectares.

The horses experienced a big change in their life conditions and now they are living in a closer way to their ecology. Clear signs of wellbeing enhance were identified since the project started in 2020. They now graze over the understory species (*Ampelodesmos mauritanicus, Brachypodium retusum, Quercus coccifera, Smilax aspera, etc.*) and their diets are supplemented with dried forage due to the low nutritional resources of this kind of forests. Next steps we are considering to improve nutrition level from the forest are sowing our own forage or reducing trees density to promote herbaceous growth.

The support received has demonstrated that it is possible to make a positive impact on ecosystems and communities, even starting from a situation with limited resources. The project aims to continue working with the community to advance fire prevention through silvopasture, nature conservation, and raising awareness about the natural values of these ecosystems.

The Forest Horses project is not just about managing vegetation and reducing fire risk; it is also about creating a sustainable model that can be replicated in other

regions facing similar challenges. By reintroducing herbivory, the project helps to restore the natural balance of the ecosystem, promoting biodiversity and enhancing the resilience of the landscape to environmental changes.

Moreover, the project has a strong educational component. Workshops and guided tours are organized to educate the public about the importance of sustainable land management and the role of herbivores in maintaining healthy ecosystems. These activities are designed to engage people of all ages, from school children to adults, fostering a deeper understanding and appreciation of the natural world.

The project also collaborates with local researchers and universities to monitor the impact of the horses on the forest ecosystem. This scientific approach ensures that the management practices are based on evidence and can be adapted as needed to achieve the best outcomes for both the environment and the horses.

In conclusion, the Forest Horses project represents a holistic approach to land management that integrates ecological, social, and economic aspects. By working together with the community, the project aims to create a more sustainable and resilient landscape, where both people and nature can thrive. The success of the project so far is a testament to the power of collaboration and the potential for innovative solutions to address complex environmental challenges.



Former vineyards are becoming shrublands and then forests in our territory. We must manage this spaces to generate diversity and a wildfire-resilient landscape.
Author: Forest Horses Association | © CC by Forest Horses Association



Temporal and permanent water ponds are key to sustain biodiversity in mediterranean environments. We take care of this spaces to help amfibian populations.
Author: Forest Horses Association | © CC by Forest Horses Association

/// Always Moving Forward ///

As Catalonia is facing an unprecedented drought, water supply for our horses is becoming one of the main threats for the project. Coordination with authorities and the ADF Forest Defense Volunteer groups is key to have access to this resource. Improving capacity for water accumulation in different structures and the design of new rain-water stock systems are the next steps to guarantee water availability for the horses.

Lack of mechanical management of the forest is another limitation we are identifying to carry out a fire-resilient forest management. The high density of pine trees forests, dead trees and the growth of plant woody cover are limiting silvopasture and increasing wildfire risk.

Management strategies relying on horse grazing need to be preceded by mechanical actions that must be included in a management plan for every forest property we are acting in. Collaboration with forest owners, search of financial support and sustainable forest management training for the volunteers are needed to make a step forward in promoting managed and functional forests.

Recently we started a collaboration with the pioneer regenerative wines of the company Familia Torres in a mechanically thinned forest next to an organic vineyard. This means a great pilot area to assess how the horses can help to control the understory growth through silvopasture.

Further information

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Acknowledgment / Contribution

Our volunteering team is helping to daily take care of the horses as well as the infrastructure and materials.
ARBA Litoral, as a local conservation group helps us protecting biodiversity. Universitat Autònoma de Barcelona (UAB), as a key partner for research around our actions, both in equid's diet and etology.

Authors: Víctor Gil, Forest Horses Association | **Partners:** PCF – Pau Costa Foundation

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The vital role of mobile pastoralism in the resilience of Mediterranean ecosystems

Mobile pastoralism to maintain Mediterranean's habitats and to enhance ecosystems capacity to adapt to climate change. A case study from Spain: Dehesa.



Lowland agro-sylvo-pastoral system: Dehesa, Spain.
Author: Concha Salguero | © Educational use, non-commercial.

Alliance for Mediterranean Nature and Culture (AMNC).
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/// Context ///

Mobile pastoralism stands out as one of the most environmentally friendly livestock production systems, contributing significantly to the mitigation of CO2 emissions and embracing low-carbon livestock practices. The practice of grazing and browsing exerts a positive influence by curbing the spread of terrestrial fuels into atmospheric ones during potential wildfires. Through the consumption and trampling of dry vegetation and underbrush leaf cover, domestic herbivores effectively reduce the horizontal and vertical continuity of the shrub layer. In addition, the migratory paths traced by mobile herders act as natural firebreaks, which are useful in preventing the rapid spread of wildfires.

Extensive livestock grazing, characteristic of mobile pastoralism, is also a powerful tool for improving soil stability, promoting restoration and strengthening resilience. By reintroducing manure into the nutrient cycle and allowing pastures to undergo rest periods, mobile herds facilitate regeneration of vegetation cover and trees. Manure application improves soil macroaggregates, strengthens resistance to compaction and increases water-holding capacity, all of which collectively enhance erosion resistance. In addition, the positive impact on soil structure is directly related to increased water storage capacity and regulation of the water cycle.

/// Solution for a Resilient Future ///

Mobile pastoralism forms a dynamic and enduring tradition that is deeply intertwined with Mediterranean landscapes and ecosystems. The core of this practice is the mobility of people and their livestock in search of forage and water resources. Although there are various forms of mobile pastoralism, including transhumance and nomadic pastoralism, the key aspect remains the cyclical return of herds to particular landscapes, even during periods of low productivity (Manzano-Baena and Salguero-Herrera, 2018).

The Iberian Peninsula boasts a rich tradition of transhumance, where domestic herbivores trace ancient routes inherited from their wild predecessors. Transhumant herds, primarily consisting of cattle or sheep, follow a seasonal migration pattern. They spend winters in lowland landscapes, particularly in Dehesas and Montados across southern regions, before migrating to northern mountain areas during the summer months (Yılmaz et al., 2019). Some transhumant households own land in Dehesas, while others lease land from private landowners for grazing purposes. In the case of common pastures, they rent land from municipalities (Yılmaz, 2019).

Migratory routes act as ecological corridors that facilitate seed dispersal and connect valuable habitats, including protected areas, semi-natural landscapes, and natural habitats (Delibes et al., 2017). As a result, they promote landscape heterogeneity, interrupting fuel continuity and reducing the vulnerability of ecosystems to large-scale fires. In addition, through seasonal migration, livestock leaves pastures before grass is scarce and before it begins to graze young saplings, allowing these trees to survive.

The abandonment of mobile pastoralism is a major cause of the recurrent fires that plague the Mediterranean region. When animals no longer consume biomass, it

remains untouched, increasing the risk of fires. For this reason, silvo-pastoral managed lands are less susceptible to fires due to the reduction of underbrush vegetation. Extensive grazing plays a crucial role in creating firebreaks and promoting tree cover (Manzano-Baena and Salguero-Herrera, 2018).

Rotational grazing practices inherent in mobile pastoralism improve also soil health and contribute to biodiversity conservation. Grazing animals stimulate nutrient cycling, improve soil structure, and promote vegetation diversity through selective foraging. Restoring vegetation cover helps to prevent floods and erosion.

In addition, manure application increases soil macroaggregates, resistance to compaction and water-holding capacity, all of which enhance erosion resistance (Blanco-Canqui et al., 2015). Healthy soils support diverse plant communities and promote carbon sequestration, thereby mitigating the impact of climate change.

Recognizing the importance of mobile pastoralism in wildfire prevention and integrating traditional knowledge with contemporary fire management strategies are essential steps toward promoting sustainable land management and conserving Mediterranean ecosystems.



Shepherding in the Shar Mountains, North Macedonia.
Author: Jovan Bozinoski | © Educational use, non-commercial.



Transhumant sheep: Dehesa (Spain).
Author: Concha Salguero | © Educational use, non-commercial.

/// Always Moving Forward ///

Mobile pastoralism offers a holistic and adaptive approach to reducing the risk of wildfires and preserving Mediterranean ecosystems. However, despite the numerous benefits offered by this practice, pastoralists and their traditional lifestyle encounter various threats. These include challenges in securing adequate land for herd maintenance and accessing traditional migratory routes, often due to land fragmentation caused by intensive agriculture, urbanization, highway construction, and large-scale infrastructure projects. Additionally, land degradation stemming from environmental issues exacerbated by the climate crisis poses significant concerns. Access to markets is limited, compounded by evolving market demands. Lastly, the lack of motivation among younger generations poses challenges to generational renewal within pastoralist communities. Future projects/research should aim to increase awareness and appreciation of the ecological, socio-economic and cultural values of mobile pastoralism among stakeholders and policy makers and develop policy recommendations to support this practice.

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Authors: Dario Pollicino | **Partners:** IUCN – International Union for Conservation of Nature

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Innovative tools for more efficient management of animals in extensive grazing

Applying Virtual Fencing, GPS data, and Precision Livestock Farming devices to optimize pasture resource utilization, improve animal welfare and promote livestock system adaptation to climate change.



Cows with VISTOCK GPS collar system.
Author: VISTOCK project | © Educational use, non-commercial.



Mugello landscape near Marradi.
Author: ilfilo.net | © Educational use, non-commercial.

/// Context ///

The VISTOCK project aimed to improve land resources and quality of life in rural areas. It encouraged technology transfer in agriculture and promoted farm competitiveness and sustainability. This is done by developing a system of new technologies and practices. These include Virtual Fencing, satellite data, modelling tools and Precision Livestock Farming devices. This system helps farmers to control grazing animals more effectively. As a result, the grazing resource is used more efficiently, animal welfare is improved and the breeding system is adapted to climate change.

The test was performed in two livestock farms located in different areas of Mugello. On the zootechnical side, the experimental activities concerned pasture management using Virtual Fencing technology. This technique uses collars from the Norwegian company Nofence®. The collars, used for the first time in Italy, let you know where each animal is in real time and control its movement without setting fixed fences. An in-depth study of the forage resource was carried out. Specifically, a protocol was developed for the collection of field data, by using traditional systems and innovative technologies (Grasshopper®). The main findings of Virtual Fencing

To develop an integrated system of innovative technologies and practices, based on the application of Virtual Fencing.

This system offers knowledge transfer to farmers for a more efficient control of grazing animals.

indicated that the animals' adaptation to the collar (in terms of sounds and shocks released by the collar when crossing the virtual fence) varies according to several factors. These are related both to the location of the two farms and probably to the age of the cattle.

On the farm located in the lowland of Mugello region, where the cattle herd was composed on average of more aged cows, adaptation to the collar encountered more difficulties. In the highlands of Mugello region, with a younger herd, after a short period of adaptation, the animals reacted favorably by staying within the virtual boundaries. By integrating these technologies with modelling and remote sensing tools, the VISTOCK methods were tested and proposed to optimize the use of the pastoral resource in the different areas surveyed throughout the grazing season. Furthermore, this allowed for supporting livestock breeders in the management of their livestock.

A protocol was developed for the collection of field data, by using traditional systems and innovative technologies.

/// Solution for a Resilient Future ///

The project aimed to characterize the forage grazing resource and identify tools for efficient farm management. Measurements were taken during the spring-summer-autumn period to monitor the growth and development of the herbaceous resource in relation to utilization and weather trends. Eight exclusion cages were placed on each farm, with further subdivision on the Valdastra farm into a continuous grazing zone and a rotational grazing zone.

These cages allowed for the measurement of grass production inside and outside the cage, to determine the amount of biomass used by the animals. To increase reliability, the cages were moved to different parts of the grazing area for more replicates and potential production data. Various methods were used to collect data on vegetation, including GPS, NDVI (Normalized Difference Vegetation Index) measurements, solar radiation measurements, herbometer readings, and quality analysis. Daily images were also obtained using digital cameras, and satellite images were downloaded for analysis. A simplified pastoral model was developed to simulate grass biomass, forage production, and soil water balance.

The project also aimed to validate the use of Virtual Fencing (VF) collars for managing grazing cattle. The collars were equipped with GPS trackers and a smartphone app that allowed farmers to set virtual perimeters. The collars would emit acoustic signals to indicate the virtual fences to the animals. If the animals ignored the signal and crossed the virtual perimeter, they would receive a slight electric shock. After a training period, the animals learned to associate the sound signal with the virtual barrier and would change direction to avoid the shock.

VF is proposed as a cost-effective alternative to physical fences, reducing the time and expenses of managing grazing animals. The project also focused on monitoring the animals' welfare in response to this new management approach in the Italian and European zootechnical context. The activities took place on two Limousin beef cow farms equipped with Nofence® collars. Thanks to the Nofence® application, it was possible to monitor the movements and behaviour of each animal in real time, recording all their interactions with the virtual boundaries in terms of the number of sounds, shocks and escapes in a free-range grazing system and in a rotational one.

How to characterize the forage grazing resource and to validate the use of Virtual Fencing (VF) collars.



Exclusion cage positioned within the grazing area.
Author: VISTOCK project | © Educational use, non-commercial.

Measurements were taken during spring-summer-autumn period to monitor growth and development of the herbaceous resource.

The agronomic surveys conducted helped characterize the two experimental farms and validate the trial technologies. Satellite data from Sentinel-2 was used to create maps based on vegetation indices, which were then correlated with vegetation characteristics measured on the ground. This relationship between the NDVI vegetation index and the LAI (Leaf Area Index) value allowed for the development of a simplified model to simulate the entire system and calculate the daily production of the herbaceous resource. The simulation model accurately predicted grazing biomass under various conditions. Additionally, high-resolution images were obtained daily from cameras installed on the farms, and these images were processed to monitor the trend of the herbaceous resource during the growing season. Grass development was monitored using the Grasshopper herbometer, and this data, along with GPS positions, was used to create vegetation height maps and production maps. Measurements were taken every 15 to 20 days to track the growth and production of the herbaceous resource throughout the season.

The results of a study on the use of Virtual Fencing (VF) for grazing herd management show promising results in terms of animal adaptation and welfare: the animals gradually became accustomed to the VF collars, resulting in a decrease in stimuli delivered by the collars, such as sounds and shocks. Density maps demonstrated that the animals predominantly remained within the virtual boundaries. In terms of animal welfare, there were no

The project aimed to validate the use of Virtual Fencing (VF) collars for managing grazing cattle.



significant differences between the control group and the group managed with VF in terms of rumination, resting, and grazing activities. However, interesting differences in behavior were observed during the grazing day, with rumination activity concentrated in the evening hours and grazing activity more frequent in the central hours of the day. Analysis of cortisol content in hair samples showed no change between the beginning and end of the test, suggesting that VF management had little impact on animal welfare. Further investigations are needed to confirm these findings.

Grasshopper® electronic herbometer.
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/// Always Moving Forward ///

With regard to the agronomic activity, possible problems were related to the use of the images acquired by satellite. The latter, in fact, were sometimes of poor quality or even unusable, due to cloudy conditions in the area of interest during the survey period. These conditions were frequent and numerous during the test period, greatly reducing the time interval between one image and the next. Nevertheless, thanks to the high temporal resolution of the Sentinel-2 satellite (5 days) and the availability of interpolation methods to obtain information between two available images, it was possible to obtain a sufficiently good curve of the vegetation indices of interest during the season. Another type of problem encountered was the use of high-resolution digital cameras. In some cases, moisture in the field caused malfunctions within the devices, resulting in the loss of some data. The sealing of the cameras with special adhesive tape made it possible to restore their functioning.

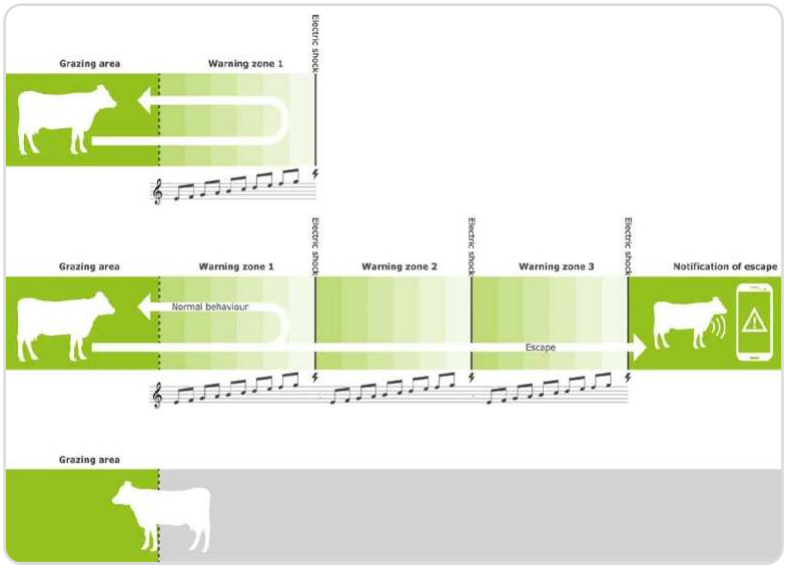
With regard to the zootechnical aspects, problems arose mainly in the use of Nofence® collars. The VISTOCK project made it possible to evaluate grazing management by means of Virtual Fencing for the first time in Italy. Consequently, the criticalities encountered may provide an important indication in the continuation of research in this field, as well as in a more strictly applicative field. Having said this, the main criticalities occurred on the Valdastra farm where the animals, in the management of virtual grazing, showed an incomplete adaptation to the collar itself. The number of shocks and escapes from the virtual fence was in fact high when compared to the animals on the AGRI.COMES farm. This result can probably be attributed to the advanced age of the cows on the Valdastra farm, which would lead to a lower adaptability of the animals to conditions other than their usual ones. Such problems were not found in other experiments, as reported in the following chapter.

Critical issues and aspects of success in order to replicate the methodology.

The high probability of successfully transferring the integrated innovation system developed with the VISTOCK project is linked to the fact that it responds to real innovation needs on the part of the livestock sector in the START LAG area and, in parallel, to the dissemination and training activities implemented during the project itself. The creation of an active cooperation between the actors of the supply chain, and between them and the world of research, has allowed to increase the project's operational spin-offs and the transferability of the system and methodologies implemented to other farm realities of the Tuscan territory, but also nationally. Numerous contacts were made by breeders in Northern and Southern Italy interested in experimenting the VISTOCK model in their farm contexts (not only beef cattle but also dairy cattle).



Pattern of virtual boundary shifts during the first part of the grazing season.
Author: VISTOCK project | © Educational use, non-commercial.



Functional diagram of Virtual Fencing collars (Nofence®).
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The VISTOCK System was developed to manage beef cattle grazing in a rational and sustainable way, taking into account the availability of fodder resources, environmental protection, animal welfare, and overall farm productivity. The system can be replicated and disseminated in other farms, thanks to the fine-tuning and application protocols derived from the project's experimentation. The project also saw the integration of various innovative tools, including Virtual Fencing collars for managing grazing animals. This has given great visibility to the Mugello livestock sector, not just within Italy but also internationally. To facilitate the transfer and dissemination of the knowledge and tools developed, dissemination and communication activities such as workshops, conferences, and seminars were organized for stakeholders, local farmers, and communities. These activities aimed to share the results, methodologies, application protocols, and challenges encountered during the project.

Cooperation allowed to increase the project's operational spin-offs and transferability of the system and methodologies.

The VISTOCK System was developed to manage beef cattle grazing in a rational and sustainable way.

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GPS collars: remote monitoring of mountain grazing

In Serra do Alvão, Portugal, the "LIFE Maronesa" project is using targeted grazing to manage the understorey, preventing fires and restoring degraded areas.



Pastoralism in Lameiro in Serra do Alvão.
Author: Daniela Parente | © Educational use, non-commercial.



Projecto LIFE Maronesa team.
Author: Daniela Parente | © Educational use, non-commercial.

/// Context ///

Traditional pastoralism is falling into disuse in northern Portugal with the decline in the rural population. The role of the herds, combined with the use of fire to control the understorey, which is vital to the resilience of the landscape by reducing the impact of fires, has been lost.

> **Technologies to improve productivity of silvopastoralism, understorey management and livestock breeder/shepherds labour**

To improve grazing conditions, the “Rebanhos +” project has been launched, using guided grazing as a tool for managing natural spaces, preventing fires in a coordinated way between neighbouring areas and restoring degraded areas. It invests in geographical information system models that allow risk prevention and adaptation to climate change through a virtual platform.

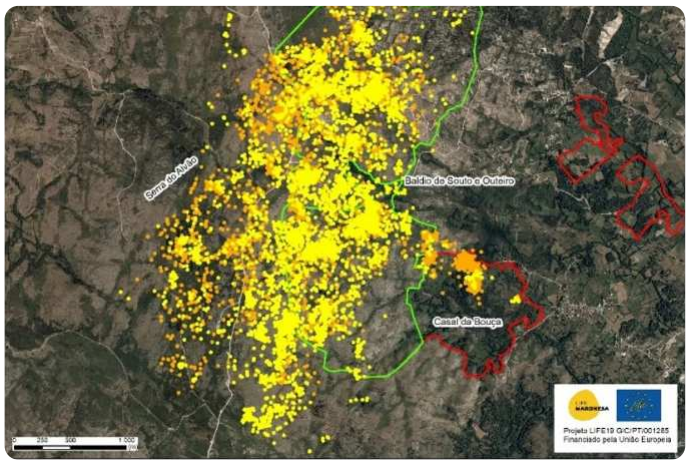
The LIFE Maronesa project also appears, promoting governance and climate information to communities in the villages of Serra do Alvão. It provides Maronesa cattle breeders with technological tools and strategies to combat climate change, an economic incentive for the return of silvopastoralism to the mountain ecosystem.

One of the aims of these projects is to test the benefits of monitoring livestock using GPS technology applied to the animals' collars. The position of the animals is recorded in real time and transmitted via the Digitanimal mobile phone application. This practice simplifies the tasks of breeders and shepherds: the animals, which graze in the baldios between April and November, are easy to find if they are far from the farm, go to other villages or cross paths with another herd, a task that used to take a lot of time. The efficiency in locating animals allows professionals to be away for other activities without worrying about losing them. The data collected from the devices is extremely useful for detecting and analysing spatio-temporal patterns of animal behaviour, vital information for improving mountain pasture management.

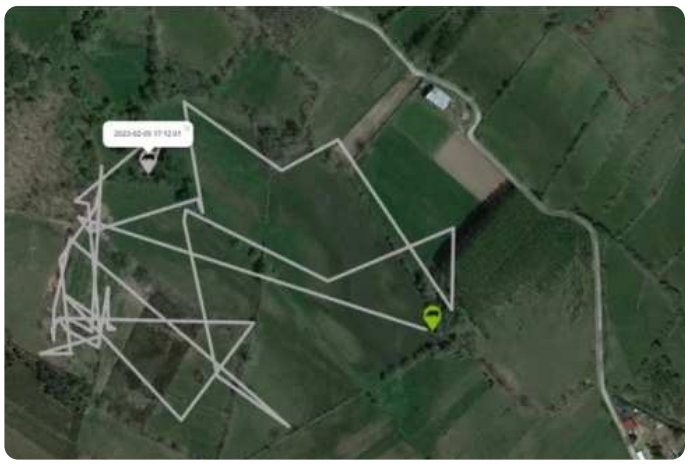
> **One of the aims of these projects is to test the benefits of monitoring livestock using GPS technology applied to the animals' collars.**

> **It invests in geographical information system models that allow risk prevention and adaptation to climate change through a virtual platform.**

GPS collars are a success story with the potential to be widely used in the future. However, there are barriers to overcome, such as the difficulty of getting good network reception in the most remote areas of the mountains. This is being addressed by working with network distributors and placing relay units in identified areas with weak signal reception.



Mapping of animal behaviour with the Digitanimal application.
Author: Not applicable | © Educational use, non-commercial.



Route recorded by the Digitanimal application.
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/// Solution for a Resilient Future ///

In the mountainous areas of northern Portugal, lameiros, private land for pasture and hay production, and baldios, collective land traditionally used for cattle grazing, are of great importance to local communities. The lameiros, which are arable land, are different from the baldios, which have no agricultural potential and are located at higher altitudes. Cattle have traditionally been key to the functioning of these lands, providing traction work and the transport of fertility. Grazing, low-intensity fires and removal of shrubs for animal bedding and fuel use controlled the shrub layer while maintaining a productive cover for grazing. The progressive depopulation of these areas, due to migration to urban centres and the ageing of the population, makes these practices less and less common. With the disappearance of grazing, animals intervene on the land, resulting in less management of the shrub cover and, consequently, more problems associated with the spread of fire.

The LIFE-Maronesa and “Rebanhos +” projects were set up to modernize and improve grazing conditions in the Alvão mountain range. “Rebanhos +” is the result of a consortium between AguiarFloresta, the Associação Nacional de Criadores de Cabra Bravia and the Associação Nacional de Caprinicultores da Raça Serrana. LIFE Maronesa, also coordinated by AguiarFloresta, brings together the Associação de Criadores do Maronês, the Instituto Politécnico de Bragança and the Casal da Bouça Livestock Farm.

One technological solution to these projects is the use of collars fitted with GPS receivers to monitor livestock. The GPS system emits a signal every 30 minutes that

A technology to control the location of grazing in real time and increase labour productivity.

With the disappearance of grazing, animals intervene on the land, resulting in less management of the shrub cover and, consequently, more problems associated with the spread of fire.

indicates the animal’s location. This position is sent to a central server, which the herders can access through an application installed on their mobile phones to see how their herds are moving in the mountains. The devices have an estimated autonomy of six months to a year. The cost per collar varies between €149.99 and €189.95, depending on the quantity purchased.

Monitoring is carried out using the Digitanimal application (https://digitanimal.pt/), which is renowned for its ease of use. It allows access to the general map showing the position of the collars, differentiated between “in good working order” and “with malfunction or lack of network coverage”. The route taken by the cattle is also recorded, making it possible to identify which areas they prefer to feed in and for how long. This type of knowledge is crucial for developing more appropriate grazing management methods. One example is information for the positioning of mobile mangers, a technical and logistical innovation also tested in LIFE-Maronesa. The monitoring is carried continuously, allowing the collection of a maximum of 17520 position data per animal per year. Such information is an opportunity to observe and study the temporal patterns in animal behavior, such as animal local preferences between day and night or during separate seasons.

The benefits to herders’ productivity are clear. Animals can stray from the herd, either by getting lost, falling asleep or being attacked. With this system, the shepherd



Applying GPS collars on goats.
Author: Unidentified | © Educational use, non-commercial.

With this system, the shepherd spends much less time searching the mountains. This frees up time for other management tasks on the farm.

One technological solution to these projects is the use of collars fitted with GPS receivers to monitor livestock. The GPS system emits a signal every 30 minutes that indicates the animal's location.

spends much less time searching the mountains. This frees up time for other management tasks on the farm. During the hay harvest period, for example, it allows the breeder to fully focus on this activity of great importance for the future of the farm in the coldest months of the year, where the productivity of the meadows is not sufficient for a good diet for his herd, and the cold and bad weather makes the animals available to spend more time on the mountain. Between the end of spring and the beginning of summer, the farmer can control and evaluate the best time to cut the grass in his plots spread throughout the village and collect the hay before it loses its moisture and nutritional quality for the herd.

/// Always Moving Forward ///

The LIFE Maronesa and “Rebanhos +” are part of the initiatives undertaken by the Terra Maronesa Community of Practice to promote the sustainability of extensive livestock farming, the improvement and conversion of mountain areas, while contributing to the economic valorisation of the activity and reducing the risk of forest fires. At the same time, these activities promote and publicise the indigenous breed of cattle “Maronesa”, originating from the northern region of Portuga, whose meat is protected by the EU’s Protected Designation of Origin (PDO) regime.

The lack of mobile network coverage in the Serra do Alvão is being an obstacle to the implementation of the LIFE Maronesa project. Without a proper network coverage for the GPS equipment, the animal tracking is compromised. This coverage problem not only affects the efficient monitoring of the animals, but also causes the reduction on the autonomy of the devices by almost half in areas with poor coverage. Ideally, the devices should have a year of autonomy. Once the battery in the GPS device runs out, the professional has to find and capture the animal on his own, which can be dangerous considering these are animals used to living outdoors. One of the ways of solving this problem is to detect and delimit areas with a poor GPS signal and to place new sigFox network retransmitters to complement the existing network. The sigFox network was here chosen because 5G coverage in Serra do Alvão is very poor. The network is designed for low-speed communication, reducing the costs and energy consumption of connected devices. Because it is based on a very narrow band, it allows devices to have a high power to penetrate obstacles, facilitating communication over long distances.

The proper functioning of the equipment requires a good signal distribution network in the mountains

The GPS collars are ultimately a tool that provides a considerable amount of information related to animal monitoring, which contribute to the future development of new methodologies in multiple areas related to silvopastoralism.



Applying GPS collars on cows.
Author: Daniela Parente | ©Educational use, non-commercial.

In the “Rebanhos +” project, the collars were used more in goat herding practice, focused to monitor the daily movements of wild and mountain goats. In this way, in addition to being able to locate the herd, the breeders were able to identify areas on their or the community’s land that their animals preferred. In this way, they improved the availability of pasture through mechanisation or the use of fire to renew it. Thus, the collars helped to increase the area under herd management and, consequently, the area protected against wildfires.

In the LIFE Maronesa project, the collars in addition to identifying the most favoured areas for the herd in the communal areas, for management interventions similar to those of the the “Rebanhos +” project, such as the use of fire, they allowed for the quantification of grazing areas, which will be used for monitoring purposes for the calculation of the carbon sequestration area and for the future re-evaluation of grazing as an ecosystem management tool.

One of the ways of solving this problem is to detect and delimit areas with a poor GPS signal and to place new sigFox network retransmitters to complement the existing network.

The LIFE Maronesa project is now halfway through and will continue until September 2025. It will continue to test and improve technological solutions to promote the practice of extensive silvopastoralism using the Maronesa breed of cattle, an autochthonous bovine breed perfectly adapted to the mountain ecosystem. To follow the latest news on these topics, visit the project website at https://www.lifemaronesa.eu/noticias/.

GPS collars are ultimately a tool that provides a considerable amount of information related to animal monitoring, contributing to the future development of new methodologies.

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Authors: Duarte Marques, Terra Maronesa; Henrique Mira Godinho, Terra Maronesa; Joana Paulo, ISA – Instituto Superior de Agronomia; Paulo Firmino, ISA – Instituto Superior de Agronomia | **Partners:** ISA – Instituto Superior De Agronomia

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Remote animal tracking to boost shepherd productivity and landscape management

GPS collars are being used as a tool to manage understorey accumulation through targeted grazing in the mountainous areas of Serra do Alvão, Portugal, increasing landscape resilience through fire prevention and restoration of degraded areas.



Maronesa cattle in Serra do Alvão, Portugal.
Author: Daniela Parente | © Educational use, non-commercial.



Maronesa cow, wearing GPS transmitting collar.
Author: Daniela Parente | © Educational use, non-commercial.

/// Context ///

Silvopastoralism has long been a traditional activity of the rural population of the northern region of Portugal, which, in addition to generating income, has played a key role in the resilience of the landscape by reducing the impact of forest fires. With the observed trend of migration to urban areas, this activity has progressively declined, and with it the management of the understorey by cattle.

With the aim of reversing this trend, the “Rebanhos +” project was created, which provides technology-based tools to improve the productivity of shepherds and to use guided grazing for the management of natural spaces. The use of such tools helps to coordinate the management of neighbouring areas, which ultimately improves fire prevention and the restoration of degraded areas. At the same time, the LIFE Maronesa project is being implemented, providing Maronesa cattle breeders with technological tools and strategies to combat climate change, and promoting governance and climate information for communities in the villages of Serra do Alvão.

One of the objectives of these projects is to test the benefits of monitoring livestock using GPS technology applied to the animals’ collars. The animals’ positions are tracked in real time and transmitted to a mobile phone application, the Digitanimal. Having this information will significantly reduce the time spent by breeders and shepherds in locating their herds, allowing professionals to focus on other activities.

/// Solution for a Resilient Future ///

The LIFE-Maronesa and “Rebanhos +” projects were set up to modernize and improve grazing conditions in the Alvão mountain range. “Rebanhos +” as created from a consortium between AguiarFloresta, the Associação Nacional de Criadores de Cabra Bravia and the Associação Nacional de Caprinicultores da Raça Serrana. LIFE Maronesa, also coordinated by AguiarFloresta, unites the Associação de Criadores do Maronês, the Instituto Politécnico de Bragança and the Casal da Bouça Livestock Farm.

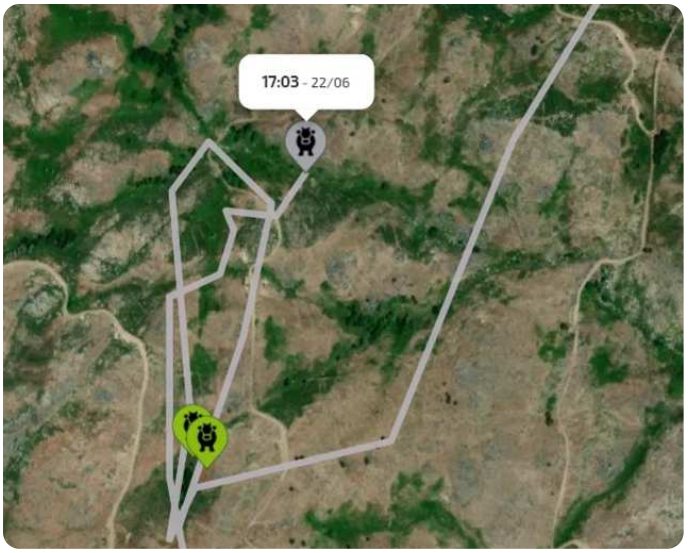
One difference from the extensive model promoted by the LIFE Maronesa project is taking into account that traditional agriculture removed fertility from the mountains, due to the needs of the communities, as the cattle returned to the villages to spend the night. The manure produced at night was used as fertilizer for crops in lower land areas. Even so, the traditional system kept an ecological balance in the mountain, enough to maintain the rotation and use of this fertility, due to the mountain in the past being subject to a greater pressure from herbivory, that is does not happen today. With rural abandonment and the decline of herbivory, more severe fires arose in the summer and reduced soil productivity.

One technological solution tested in these projects was the use of collars fitted with GPS receivers to monitor livestock. The GPS system emits a signal every 30 minutes indicating the animal’s position to the herders, who can track their herds in the mountains using the Digitanimal mobile phone application (https://digitanimal.pt/), which is renowned for its ease of use. The application provides the general map showing the position of the collars, differentiated between “in good working order” and “with malfunction or no coverage”. The route taken by the cattle is also recorded, making it possible to identify preferred areas for feeding and for how long. This information is vital for developing and improving grazing management methods. One example is the use of this information to locate mobile mangers a technical and logistical innovation also tested in LIFE-

Maronesa. The GPS devices have an estimated autonomy of six months to a year and cost between €150 and €190 per unit, depending on the quantity purchased.

Trials of the devices have shown clear benefits to herders' productivity. With the system, animals that might stray from the herd, either because they get lost, fall asleep or are attacked, are found much more quickly by the shepherds in the mountains. This allows the professionals to spend time on other management tasks on the farm and reduces their worries. Two practical examples show the benefits of GPS:

- Between the end of spring and the beginning of summer, the farmer can check and assess the best time to cut the grass on his plots spread around the village and collect the hay before it loses its moisture and nutritional quality for the herd.
- In the hay harvest period, when the breeder can fully focus on this activity of great importance for the future of the farm in the coldest months of the year, where the productivity of the meadows is not sufficient for a good diet for his herd, and the cold and bad weather (frost, cold wind and mud) causes animals to leave for the mountains later and return earlier.



Controling animal activity with Digitanimal application.
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Installing the collar devices in the animals.
Author: Daniela Parente | © Educational use, non-commercial.

/// Always Moving Forward ///

Poor mobile phone coverage is an obstacle to the implementation of the LIFE Maronesa project in Serra do Alvão. The GPS equipment requires good network coverage, essential for efficient animal tracking and for the autonomy of the devices, which can be reduced by almost half in areas with poor coverage. When the battery runs out, the professional has to find and capture the animal on his own, which can be a slow process, but also dangerous as these are animals used to living outdoors. A solution is to identify and delineate the areas with a poor GPS signal and place new sigFox network retransmitters to complement the existing network.

GPS devices provide a great deal of information for monitoring animals. In the 'Rebanhos + project', they were used to monitor the daily movements of wild and mountain goats, allowing breeders to identify the areas preferred by their animals. In this way, they improved the availability of pasture through mechanisation or the use of fire to renew it. In the LIFE Maronesa project, in addition to identifying the herds' preferred areas for management interventions, they allowed the quantification of grazing areas, which will be used to monitor and calculate the carbon sequestration area and to re-evaluate grazing as an ecosystem management tool.

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Integrated crop-livestock farming systems

Integration of livestock and crops as a viable alternative to specialized systems that can improve resource efficiency and ecosystem services. A case study from Lemnos, Greece.



Farmer Field School on livestock management.
Author: Ibtissam Bouseta | © Educational use, non-commercial.

Alliance for Mediterranean Nature and Culture (AMNC).
Author: AMNC | © AMNC

/// Context ///

Mediterranean agriculture faces a multitude of challenges, including loss of biodiversity, overexploitation of freshwater resources, disruption of nutrient cycles, soil degradation, and altered fire patterns. These problems are exacerbated by factors such as water scarcity, heavy reliance on energy imports, and the prevalence of highly specialized agroecosystems with low diversity. Against this backdrop, the adoption of integrated forms of agriculture, such as the Mandra system in Lemnos (Greece), emerges as a promising avenue for reinvigorating the sustainability of agricultural landscapes and strengthening resilience against the impacts of climate change.

Integrated farming systems involve the simultaneous cultivation of different crops (which include cash crops, food crops and energy crops) along with a variety of livestock, while implementing comprehensive methods to recycle animal waste. The overall goal is to optimize resource utilization, particularly with regard to nutrients, reduce dependence on external inputs such as fertilizers, pesticides and concentrated feed, and sustain favorable environmental outcomes.

Through the adoption of complementary agricultural practices between crops and livestock, several key ecosystem services are realized. These include erosion control, biological regulation (including pollination) and maintenance of soil fertility, which includes both soil structure and nutrient cycling.

/// Solution for a Resilient Future ///

The Mediterranean region has long been admired for its unique agricultural practices, deeply rooted in tradition and sustainability. Among these practices, the mandra system stands out as a testament to the resilience and adaptability of Mediterranean agriculture. Characterized by its mixed crop-livestock land use, the mandra system embodies the principles of diversification and complementarity, contributing to both ecological sustainability and community livelihoods.

At the heart of the mandra system lies the ‘mandra’ itself, a traditional farming structure found predominantly on the island of Lemnos. The mandra serves as a multifunctional area enclosed by dry-stone walls, housing essential components such as animal sheds, shepherd huts, and barns. Surrounding the mandra are pastures and arable lands cultivated with cereals and leguminous crops.

Diversification is best represented by the close co-existence of crop fields and pastures. Crop rotation, intercropping, and fallow practices enhances soil fertility and minimize the risk of nutrient depletion, contributing to sustainable land management (MedINA, 2018; MedINA, 2020).

Livestock harmonious integration with crop cultivation epitomizes resource use efficiency. Photosynthesis carried out by grasses promotes the conversion of carbon dioxide, water, and minerals into biomass. Legume species act as an alternative to mineral fertilization by fixing nitrogen, resulting in synergies that benefit biomass production. Crop residue management further enhances farm sustainability, as straw and stubble remaining on fields can serve as fodder for grazing livestock. Finally, manure improves soil fertility and water retention, mitigating the impact of drought-

induced soil degradation and increasing long-term productivity. Therefore, grazing animals help close the nutrient cycle and control weeds, reducing the need for mechanical interventions such as tillage and ploughing, which result in soil disturbance (Bonaudo et al, 2013).

Integrated crop-livestock systems also play a crucial role in the Mediterranean as they contribute to conserving a wide biodiversity of species and breeds of domestic animals. These breeds often exhibit adaptability to marginal areas that might otherwise be abandoned due to agricultural limitations. Furthermore, their ability to withstand increasing temperatures and reduced water availability underscores their importance in the face of climate change challenges (Bernués et al, 2011).

In light of the increasing incidence forest fires in the Mediterranean, livestock grazing is acknowledged as a valuable tool in fire prevention as it helps reduce the build-up of combustible vegetation, such as grasses and shrubs, and create firebreaks (Bernués et al, 2011).

In conclusion, integrated systems provide ecosystem services such as soil conservation, biodiversity conservation, and carbon sequestration, contributing to environmental resilience and climate change mitigation. Agroecological practices, such as rotational grazing and cover cropping, enhance ecosystem functions and reduce vulnerability to droughts.



Typical mandra of Lemnos Island.
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Typical mandra of Lemnos Island.
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/// Always Moving Forward ///

The ecological and heritage importance of crop-livestock systems is threatened by the intensification and modernization trends that changed the agricultural landscape in the second half of the 20th century. These same trends are behind the increasing abandonment of rural areas and the decline of animal husbandry, leading to the rapid standardization and homogenization of agricultural landscapes (Martín et al., 2016). In addition, the investment and know-how required to switch to integrated systems is often a major obstacle to sustaining the practice on small farms.

To revitalize this practice and reverse the deterioration of key ecosystem services, such as soil and water quality conservation, caused by specialized farming systems, it is paramount to strike an effective and sustainable balance between environmental and socioeconomic goals. Farmers must be adequately rewarded for their contribution to maintaining cultural landscapes and biodiversity. A key step would be to assess the positive externalities generated by these systems that help to tackle droughts and fires. Measuring the benefits of this practice in economic terms would help promote the creation of agricultural and environmental policies that compensate farmers for their provision of public goods.

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Author: Dario Pollicino | **Partners:** IUCN – International Union for Conservation of Nature

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Reaping the benefits of agropastoralism: A case study of the Mandra system in Lemnos, Greece

Empowering communities, preserving Biodiversity, and safeguarding Lemnos' distinctive landscape through the Mandra system.



Old Mandra in Tsimandria.
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Mediterranean Institute for Nature and Anthropos.
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/// Context ///

The goal of achieving a harmonious relationship between man and nature is being challenged by the climate crisis and the risks posed by uncertain socio-economic development trajectories. As a result, it is crucial to adopt integrated approaches to establish food production systems that show resilience not only to climate change, but also to broader global changes and resource depletion. This is especially imperative for Mediterranean island communities, which are becoming particularly vulnerable to exogenous pressures.

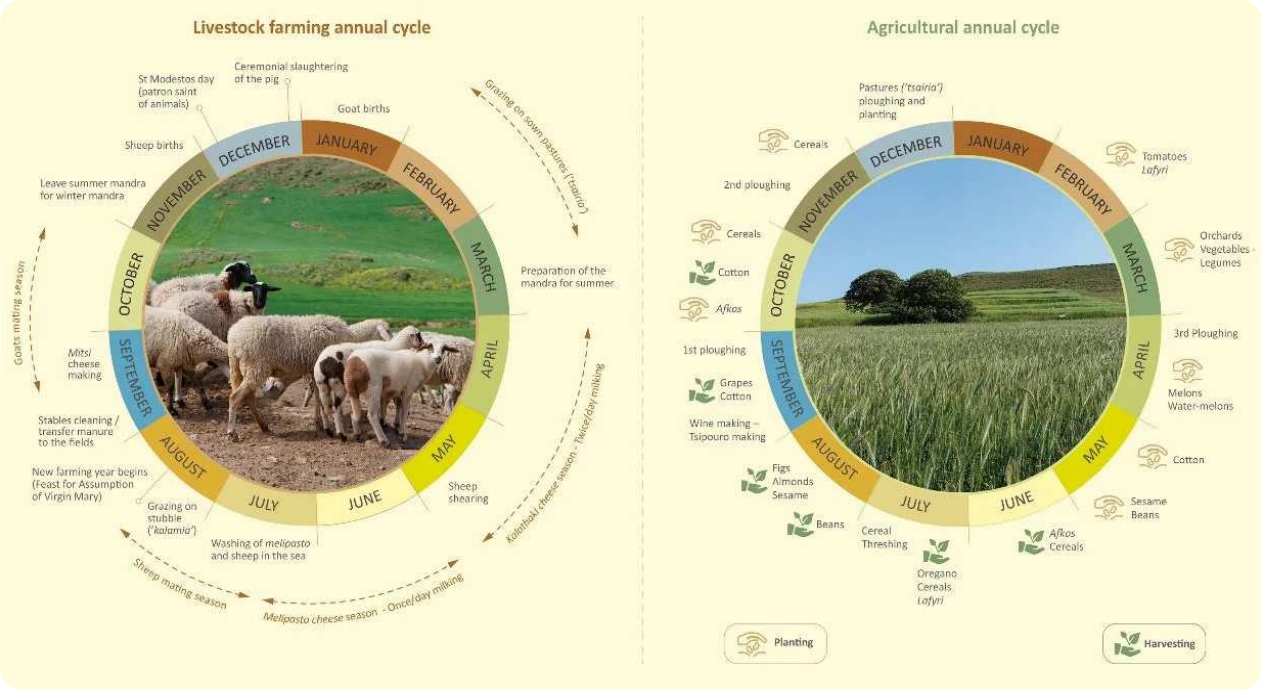
> **An integrated approach to sustain Lemnos' rural environment, enhance resilience, and tackle resource depletion.**

The agropastoral sector can be an essential resource for the well-being and prosperity of the environment and local populations. This importance is particularly evident in Lemnos, where a vibrant farming community is committed to preserving a traditional agropastoral system and maintaining sustainable levels of agricultural production, the “Mandra system”.

> **The Mandra is a key aspect of Lemnos' heritage that plays a fundamental role in promoting the sustainability of the island's rural environment.**

> **The agropastoral sector can be an essential resource for the well-being and prosperity of the environment and local populations.**

The Mandra is a key aspect of Lemnos’ heritage that plays a fundamental role in promoting the sustainability of the island’s rural environment, addressing some of the main challenges facing Mediterranean agriculture, such as loss of biodiversity, soil degradation, drought, altered fire patterns and scarcity of freshwater resources. It is based on two primary characteristics: diversification and complementarity. Diversification involves the utilization of various crop types and livestock breeds, along with practices such as crop rotation, intercropping, and fallow land usage. These methods serve to preserve and enrich the soil, safeguard biodiversity, enhance landscape structure, and mitigate erosion. Complementarity, on the other hand, revolves around a mixed crop-livestock land use system, wherein livestock graze in arable fields post-harvest, fallow lands, or grasslands. This practice contributes to crop productivity and soil health by providing natural fertilization through green manure and livestock manure. Moreover, it enables farmers to diversify production options, thus minimizing production risks, fostering biodiversity, promoting landscape diversity, and reducing the likelihood of wildfires.



The annual cycle of Mandra practices. Author: MedINA © Educational use, non-commercial.

/// Solution for a Resilient Future ///

In the western region of Lemnos, characterized by rugged terrain and sparse evergreen vegetation, livestock farming predominates, with sheep comprising 83% of the island's livestock. This is supplemented by the cultivation of arable crops, primarily for the production of animal fodder. In contrast, the central and eastern parts, featuring flat landscapes and fertile soils, are dominated by a mosaic of lowland farmland. Here, livestock breeding occurs in smaller areas. These farmlands serve dual purposes: producing fodder for local livestock farms (e.g., barley and oats) and cultivating various commercial (mainly rain-fed) crops like wheat, pulses, vineyards, and sesame.

Local farmers in Lemnos have adapted to the island's environmental and socio-cultural conditions by establishing a mixed crop-livestock land use system centered around the traditional concept of the 'Mandra'. The Mandra encompasses a multifunctional area enclosed by dry-stone walls. Within the Mandra, there are facilities such as animal sheds, farmer's/shepherd's huts (referred to as 'kehayias' by locals), and barns. Surrounding the Mandra are pastures and/or arable lands cultivated with cereal and leguminous crops for both fodder and human consumption. The Mandra serves as the central functional element around which Lemnos' traditional extensive agro-pastoral practices revolve.

Agropastoralism as a sustainable alternative to specialized agriculture. A case study from Lemnos, Greece

Farmers in Lemnos have adapted to the island's environmental and socio-cultural conditions by establishing a mixed crop-livestock land use system centered around the traditional concept of the Mandra.

The two main characteristics of this traditional 'Mandra system' are diversification and complementarity.

Diversification occurs by means of the coexistence of cultivated fields and pastures, generating a mixture of land uses even in the predominantly pastoral areas of Lemnos. This diversification results from both the mosaic-like land-use pattern and island-specific practices such as crop rotation between cereals and legumes, selection of native crop types, intercropping, and fallow land management.

These practices have been used in order to sustain soil quality, reduce soil erosion, and increase biodiversity. Crop rotation represents a biodiversity-friendly weed and pest control strategy. In addition, the interchange of cereals and legumes in cultivation allows to preserve fertility of cultivated soils. Microorganisms that form tubercles in the roots of legumes, can capture nitrogen (N) from the atmosphere, enriching the soil with this valuable component. Finally, the practice of fallow land management enhances moisture retention and promotes the colonization of fields by diverse species of wild plants and animals.

Complementarity is evident in the intricate mosaic of land use, where farming and livestock systems are intertwined. Farmers have historically maximised land



Traditional Mandra in Repanidi.
Author: MedINA | © Educational use, non-commercial.

productivity by integrating livestock farming into primary agricultural practices. This approach, characterized by semi-extensive animal husbandry, entails livestock grazing within fallow arable fields or feeding on straw and stubble left on fields post-harvest. Additional grazing needs are met by using neighbouring grasslands.

Free-range grazing has played a pivotal role in preserving natural grasslands, which harbour a substantial portion of European biodiversity. These grasslands offer optimal conditions for a wide array of habitats and species, particularly birds and invertebrates. The production of

The two main characteristics of this traditional 'Mandra system' are diversification and complementarity.

fodder contributes to the productive use of rural areas and to crop diversity, indirectly protecting natural grasslands from overgrazing. Furthermore, grazing animals on cultivated land not only naturally fertilize the soil with their manure but also facilitate the dispersal of various living organisms across extensive areas, including seeds and other organisms. This grazing activity helps mitigate the accumulation of combustible vegetation, such as grasses and shrubs, while also establishing firebreaks.

Another noteworthy aspect is the management of natural and semi-natural elements. The "trafoi" of Lemnos are uncultivated strips of land, typically elevated, that act as boundaries between fields. These strips serve as biodiversity hotspots with indigenous vegetation, providing habitat and refuge for numerous animal species, particularly invertebrates. Additionally, they contribute to pest control by harboring beneficial insects that prey on pests.

/// Always Moving Forward ///

In recent decades, changes in the global food system, combined with European policies, in particular CAP reforms, have to a large extent led to the intensification and simplification of agriculture or the abandonment of rural and less productive areas. Consequently, the industrialisation of agricultural production has led to the decline of traditional farming practices, characterised by labour-intensive, environmentally specific, multifunctional, and complementary land management.

The main challenge facing Lemnos today is to effectively address all aspects of sustainability, striking a delicate

Governance innovations to strike a delicate balance between environmental, social and economic objectives.

balance between conservation and economic objectives through a development strategy tailored to the area. Such a strategy requires a comprehensive approach that:

- Carefully considers local landscape realities and resource management systems.
- Advocates a nuanced set of legal, political and support mechanisms.
- Ensures land tenure and access to crucial resources and inputs (e.g. water, seeds, etc.).
- Cultivate value-added products, including their marketing and branding.
- Encourage the growth of local businesses, agro-tourism, and similar activities.

MedINA (Mediterranean Institute for Nature and Anthropos) has been instrumental, particularly through its involvement in the Terra Lemnia project, concluded in 2022, in fostering a shared vision for the sustainable development of Lemnos. This vision centers on the conservation and restoration of extensive agropastoral practices that not only support local biodiversity but also define the distinctive landscape of the island.

As part of the Terra Lemnia project, MedINA and its partners developed a Guide and Standard of Good Practices, showcasing the traditional farming techniques embraced by Lemnos farmers, which have shaped the island's agricultural landscape. The Standard served a



Terra Vita Certification Label.
Author: Terra Lemnia project | © Educational use, non-commercial.

dual purpose: laying the groundwork for the creation of the Land Stewards Network, a voluntary alliance of farmers dedicated to implementing these practices, and establishing the foundation for the Terra Vita Certification System.

This certification is unique, as it seeks to safeguard food produced in Greece using traditional agricultural management methods that benefit biodiversity and the landscape, while also promoting the local gastronomic identity of each region. It encompasses two types of businesses: those in the primary sector of agricultural and livestock production, as well as enterprises in the secondary sector engaged in processing, packaging, and preparing agri-food products using raw materials. Currently, the certification is operational in Lemnos and Kythira. Over 40 producers have expressed interest, with 14 already certified and others undergoing evaluation.

The main challenge facing Lemnos today is to effectively address all aspects of sustainability, striking a delicate balance between conservation and economic objectives.

Given the challenges faced by the Mandra system, including its low economic viability, and resulting rural depopulation, the market and governance innovations outlined above offer potential solutions to these pressing issues. The certification system holds the promise of revitalizing rural areas economically, motivating individuals to engage in agriculture, and facilitating the intergenerational transmission of traditional knowledge or attracting new entrants to the field. Recognizing the remarkable contributions of farmers and incentivizing them through market-driven mechanisms may serve as a pathway to environmental conservation while ensuring the economic sustainability of agropastoral systems, as evidenced by the initiatives spearheaded by MedINA.

This certification is unique, as it seeks to safeguard food produced in Greece using traditional agricultural management methods that benefit biodiversity and the landscape.

Further information

All data presented in this factsheet originate exclusively from MedINA publications (https://med-ina.org/publications/) and the resources developed within the framework of the Terra Lemnia project (https://terra-lemnia.net/en/reports/).

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Authors: Dario Pollicino | **Partners:** IUCN – International Union for Conservation of Nature

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Silvoarable system in Puig-Reig (Barcelona): diversifying cereal production with valuable broadleaves

Silvoarable Systems.



Figure 1. Aerial image of silvoarable system in Can Pallot (Puig-Reig, Barcelona province)
Author: ICGC | © CC BY 4.0



Figure 2. Rows of valuable broadleaves (Hybrid walnut and Common ash) intercropped with cereals in Can Pallot (Puig Reig).
Author: AGS-CTFC | © CC BY 4.0

/// Context ///

Agroforestry systems are the deliberate combination of woody vegetation with agricultural or livestock production to obtain benefits from their interactions. Among them, silvoarable systems combine crops with woody vegetation, which can be arranged in the field perimeter, in rows (alley-cropping), in groups or dispersed, and can serve multiple yet compatible purposes:

- Production (timber, fruit, forage, mushrooms)
- Protection (biodiversity, soil, water, animal welfare, windbreak)
- Landscape improvement

Silvoarable systems offer many benefits compared to conventional cropping:

- Increase in overall productivity, thanks to the complementarity in using light, water and nutrients in time (different phenology) and space (vertical overlapping)
- Soil protection against erosion, and water protection thanks to leachates filtering
- Improved biodiversity: system diversification, ecotones creation, restoration of trophic chains
- Improvement of the crop microclimate: buffered temperatures, less wind exposure
- Increased C fixation in soil and in timber

The silvoarable demonstration system at Can Pallot farm was implemented in 2014 under LIFE Farms for the Future (futuragrari.cat/16) and is currently being monitored under LIFE AgroForAdapt (agroforadapt.eu). It combines winter cereals with rainfed walnut and ash for valuable timber production. Overall tree mortality is 24%, with average diameter growth of 0.5 cm/year. No relevant interactions between trees and crops have been observed so far.

/// Solution for a Resilient Future ///

The Can Pallot farm in the municipality of Puig-Reig (Barcelona province) is located at the coordinates: 41.981309, 1.917696, with an area of 1.5 hectares. This system consists of an alley cropping system, with 3 rows composed of various arrangements of hybrid walnut and Common ash, intercropped with winter cereals (rotation of wheat, barley and oat), in a 18 x 4 m or 18 x 2.5 m frame (Figures 1 and 2). We are using two different frames to assess their effect on various ecosystem services, including production, leachates filtration and improvement of the microclimate.

The main physical and climatic features are:

- Mean altitude: 470 m
- Average slope: 9%
- Aspect: southeast
- Physiographic position: valley floor – lower slope
- Classification of climate (Papadakis): Mediterranean temperate

Average annual temperature [coolest month; hottest month]:

- 12.7ºC [3.5ºC; 21.5ºC].
- Annual [summer] rainfall: 675 mm [190 mm].

Soil characterisation:

- Soil classification (WRB): Eutrophic Leptosol (LP-eu) on sandstone and shale (W7a).
- Base geology: Marls, siltstones and gravels with intercalated conglomerates
- Texture (USDA): Loamy-sandy (19% clay, 24% silt, 57% sand)
- pH: 8.3
- Organic matter: 2.0%
- Other relevant soil data: 31% carbonates; 19% stoniness.

Before tree planting, the land was cultivated with rainfed winter cereals (wheat, barley and oat).

The tree plant material, both aimed for valuable timber production, is:

- Hybrid walnut (Juglans x intermedia Mj-209xRa) sized 40-60 cm bare rooted.
- Common ash (Fraxinus excelsior) in a 300 cm3 container.

The soil preparation method was mechanised pit digging (40 x 40 x 40 cm). Right after planting, we installed a black polyethylene mulch sized 100 x 100 cm and individual 150 cm high mesh-wall tree shelter. The tending of the trees consist of an annual pruning between the years 1-15.

The main results so far are:

- Common ash: 26% mortality.
- Average diameter at breast height (1.3 m): 4.6 ± 0.2 cm (average growth: 0.5 cm/year).
- Average height: 4,1 ± 0,1 m (average growth: 43 cm/year)
- Hybrid walnut: 22% mortality
- Average diameter at breast height (1.3 m): 4,8 ± 0,3 cm (average growth: 0,5 cm/year)
- Average height: 3,3 ± 0,2 m (average growth: 31 cm/year)
- Cereal: average production: 2,200-2,800 kg/ha grain; 1,800-2,200 kg/ha straw.

For the moment, we have perceived no clear impact of the trees on crop yield, although the severe drought of the last 3 seasons (2021-23), with long periods of high temperatures and uneven precipitation distribution have reduced tree growth and have made it difficult to extract meaningful conclusions with regard to the crop-tree interactions. We are using two different frames to assess their impact on different ecosystem services, including production, leachate filtration and microclimate improvement.



Figure 3. Soil preparation with a backhoe excavator in Can Pallot site.
Author: AGS-CTFC | © CC BY 4.0



Figure 4. Common ash with a mesh-walled individual tree shelter in Can Pallot site.
Author: AGS-CTFC | © CC BY 4.0

/// Always Moving Forward ///

Agroforestry systems are identified in the EU Green Deal (and in the Strategies developing it) as an eco-intensification practice to be promoted in order to address simultaneously climate change adaptation and mitigation, biodiversity conservation and diversifying farm income. These systems are attracting major interest because of their versatility and compatibility with other agroecology practices (regenerative and conservation agriculture, organic farming…).

However, the shift from monoculture crop farming to silvoarable systems comes at a cost: adding trees to a field requires thorough planning (choice of species, tree arrangement, planting techniques), an initial investment and a dynamic long-term management, of each component individually and of their interactions, which will evolve over time.

When designing an alley cropping system, an important decision to be taken is the distance between the rows of trees, which must be chosen so that they do not interfere with mechanisation and do not require additional passes; the width of the machinery must therefore be taken into account. A management challenge is to control spontaneous vegetation in the space between two successive trees in a row.

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Acknowledgment / Contribution

The Can Pallot silvoarable system was established in the framework of LIFE Futur Agrari project (LIFE12 ENV/ES/000647; 2013-18). Currently, its monitoring and maintenance is carried out within LIFE AgroForAdapt project (LIFE20 CCA/ES/001682; 2021-26). Both projects are funded by EU's LIFE Programme.

Authors: Guillem Llena; Jaime Coello – CTFC | **Partners:** CTFC – Forest Science and Technology Centre of Catalonia

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Vitiforestry practices for climate resilience in the Mediterranean region

Integrating Agroforestry to Enhance Sustainability and Productivity in Mediterranean Vineyards.



Figure 1. Pine vitiforestry; Restinclières – Occitanie region.
Author: ARTE TV – https://www.youtube.com/watch?v=qkbQ4b_97q4
© Educational use, non-commercial.



Figure 2. Olives in vineyards mixed farming systems used to be the norm across the region – and now they might have a comeback as vitiforestry gains traction!
Author: Unidentified | © Educational use, non-commercial.

/// Context ///

As the Mediterranean region is experiencing significant challenges due to climate change, traditional agricultural systems – particularly vineyards – are under threat. In response to these challenges, the ancient – yet innovative – practice of vitiforestry, is emerging as a promising solution to enhance the climate resilience of Mediterranean viticulture. Vitiforestry involves integrating the strategic planting of trees and shrubs within and around vineyards, leveraging centuries-old agricultural traditions to create more diverse, productive, and sustainable landscapes.

The introduction of trees can create a more favourable microclimate for grapevines, reducing heat stress and conserving soil moisture. Moreover, the presence of trees can improve soil structure and fertility, leading to healthier vines and potentially higher combined yields on the same land area. Lastly, vitiforestry promotes greater biodiversity, which can help control pests naturally and reduce the need for chemical inputs.

Farmers can benefit significantly from implementing vitiforestry practices in their vineyards. Such management strategies can improve water retention in the soil, reducing irrigation costs and enhancing drought resilience. Healthier soil and improved microclimates can lead to better grape quality, reduce yield losses, translating into increased profits. Additionally, incorporating fruit or nut-bearing trees alongside grapevines can provide additional income streams, helping to stabilise farm revenue. Lastly, a more diverse ecosystem can attract beneficial insects that help control pests, reducing the need for chemical pesticides and lowering production costs.

By adopting vitiforestry, farmers can create a more resilient and sustainable agricultural system that not only protects their livelihoods but also contributes to the preservation of the Mediterranean landscape and its rich cultural heritage.

Drawing inspiration from the six indicators of sustainable development listed in the EU Taxonomy Regulation, as illustrated in the 'Brno Agroforestry Declaration', this factsheet highlights how vitiforestry may become a game changer in the region.

Adapting Mediterranean Viticulture to a Changing Climate.

A pine-vine vitiforestry system (Figure 1) contributes to enhancing biodiversity, improving soil health, and providing shade to reduce heat stress on grapes.

Unlike a pine-vine vitiforestry system, the integration of olives in vineyards (Figure 2) provides additional income through the production of olives for oil or table use.

/// Solution for a Resilient Future ///

The benefits of vitiforestry practices are multifaceted. Of notable importance are those in the area of:

Climate change mitigation
By integrating species like olives, pines, or oaks, winegrowers can significantly increase carbon stored in soil and tree biomass. In the long run, this improves soil health through organic matter from decomposed leaves and branches. Integrating trees with livestock grazing creates natural fire breaks around vineyards, reducing fuel loads and mitigating wildfire risks, which are increasingly common due to climate change. The 'Zebra', 'Donut' or 'Teardrop' approaches are some of the most common. Even poultry can play a role; they can eat grass/weeds, reducing pest pressure while fertilising the soil.

Climate change adaptation
Trees act as natural barriers against wind, protecting grapevines from hot, dry gusts that can desiccate grapes and reduce yields. This wind protection helps maintain a stable microclimate, reducing stress on the vines and improving grape quality. In spring, hedges, buffer strips or windbreaks provide essential frost protection by creating a microclimate that safeguards buds against late frosts. Such tree-based landscape features also shield grapes from extreme heat during summer months, mitigating the effects of heat waves and mega-droughts. The shade from trees helps maintain cooler temperatures, preventing early bud break and ensuring balanced sugar and acidity levels in grapes. The relevance of the microclimate is also reflected on the quality of the wines: tree transpiration refreshes the vineyard microclimate, maintaining humidity and lowering temperatures. This process can lead to higher-quality must with lower alcohol content and higher acidity, resulting in more balanced wines.

Sustainable water resources
The root systems of trees enhance soil water retention by improving soil structure and allowing better water infiltration. This is particularly beneficial in Mediterranean regions facing water scarcity, as it reduces the need for irrigation and increases resilience to drought.

Soil, water, and atmospheric pollution
Vitiforestry reduces the need for chemical pesticides by attracting beneficial insects, birds, and bats that control vine pests naturally. This ecological balance promotes a healthier vineyard ecosystem and minimizes environmental impacts. Moreover, integrating trees contributes to a resilient soil microbiome, fostering beneficial microorganisms that help vines combat diseases like rot. A healthy microbiome enhances nutrient cycling and soil fertility, leading to healthier vines and better grape quality.



Domaine Vallot is one of the oldest domaines in the Côtes du Rhône (France). This vitiforestry system produces organic, biodynamic grapes for wine production.
Author: Domaine Vallot | © Educational use, non-commercial.

Protection of biodiversity and ecosystems
Vitiforestry promotes biodiversity by creating diverse habitats for various species. This integration of trees, shrubs, and cover crops supports a wider range of flora and fauna, improving pest control, pollination, and overall ecosystem health.

The circular economy
Vitiforestry offers opportunities for economic diversification through the sale of fruits, nuts, and timber from trees. Farmers can generate additional income streams, reducing reliance on grape production alone and enhancing financial resilience.

Rural socioeconomics
Implementing vitiforestry fosters community engagement and education on biodiversity and sustainable practices. Local workshops and educational programs can raise awareness, encouraging more farmers to adopt these practices.
The integration of trees also enhances the landscape's aesthetic value, attracting tourism and promoting regions as destinations for recreational activities – as well as nature conservation, further supporting local economies.

Innovative Vitiforestry Practices for Climate Resilience in Mediterranean Vineyards.

Healthier soil and improved microclimates can lead to better grape quality, reduce yield losses, translating into increased profits.



In Italy, 'Di Filippo' winery relies on geese for pest control.
Author: Vini Di Filippo | © Educational use, non-commercial.

> **"The vineyard is a whole ecosystem, a landscape: we're not here just to harvest grapes." Anaïs Vallot, Domaine Vallot.**

Skills, policies, and generation renewal
Training specialists in area of vitiforestry is of particular relevance in the context of the high workload needed to manage such farming systems, and the shortage of skilled workers in agriculture. Digital tools and models are being developed to help winegrowers design optimal vitiforestry systems tailored to their local climate, soil conditions, and production goals. These decision support systems enable more informed planning and implementation of climate-smart agroforestry practices. An example of an accessible vitiforestry electronic library has been created by the 'Sustainable Wine Roundtable' and be used freely by anyone in the industry.

/// Always Moving Forward ///

To drive wider adoption of vitiforestry, researchers, policymakers, and industry stakeholders should intensify their efforts to address key barriers, such as knowledge gaps, financial constraints, and regulatory hurdles. The potential is huge: more than 2/3rds of EU's vineyards are in the Mediterranean basin, covering an area larger than Slovenia! If half of the vineyards area from the region will transition to vitiforestry, more than 30 million trees could be planted across the region, having the potential to store the carbon emitted from 11 million passenger vehicles in tree biomass alone!

Several EU-funded initiatives are demonstrating the potential of vitiforestry and promoting its replication across the region. Moreover, hundreds if not thousands of vineyards – some of which are flagged in the above-mentioned e-library – already boast vitiforestry systems in the EU and beyond, as well as around the world (around 1.5% of U.S. farms reported using agroforestry).

Some priority areas for targeted efforts are:

- Addressing regulatory barriers, by incentivising vitiforestry through Common Agricultural Policy subsidies or tree-planting schemes. Involving regional administrations, farmers and landowners organisations is key to accelerating progress when establishing new vitiforestry systems in existing or abandoned vineyards.
- Developing decision support tools and guidelines, relying on EU-funded initiatives such as the VINEAS platform co-designed in the MEDCLIV project. Demonstrating the potential of vitiforestry and promoting its replication across the region through peer-to-peer knowledge is key – and such initiatives are crucial for providing winegrowers with the necessary tools and guidelines to effectively implement vitiforestry practices in their vineyards (e.g. which tree species should be planted, how they should be managed).
- Establishing certification and traceability and empower consumers to have access to clearer, accessible information about the efforts done by vinegrowers practicing vitiforestry. While labels are seen as tools that may enhance consumer confidence and support the market demand for sustainably produced wines, initiatives such as the 'Bee friendly wine' in the US or the 'HVE' certification in France are created to promote an environmentally friendly approach to wine production. What about having a 'vitiforestry' label?

> **Scaling up vitiforestry across the Mediterranean and beyond.**

> **Vitiforestry is emerging as a sustainable solution to the limitations of monoculture vineyards, blending tree cultivation with vine growing to foster biodiversity and environmental health (Vinerra).**



To bolster landscape resilience amid escalating wildfire threats, a farmers association (Raïm +500) in Spain uses vitiforestry-inspired practices.
Author: Angela Llop | © Educational use, non-commercial.

- Exploring innovative business models and marketing strategies to capitalise on the benefits of vitiforestry. By promoting the unique qualities of wines produced in vitiforestry systems – as well as the environmental benefits of such production systems, wineries can attract environmentally conscious consumers.
- Promoting research and innovation focused on key research gaps, such as the role of various tree species in pest control – or the water use efficiency at landscape level. Safeguarding the future of such iconic agricultural landscapes requires continued investment in research and innovation, in view of ensuring that vitiforestry may be scaled rapidly.
- Fostering knowledge-sharing and capacity-building is critical to ensure that best practices are disseminated and adopted widely across the Mediterranean wine sector. The role of forestry experts and technicians is crucial – as they can contribute to training the agricultural workforce working in the wine sector and help them managing their trees on agricultural land.

> **"We're not inventing anything; it's more a matter of recreating landscapes as they existed some 50 years ago." Pierre Hermans, head of the vitiforestry program for Reforest'Action's.**



Illustration from 'Tacuina sanitatis' – 14th century; trees were used as support for vines, which were believe to be less susceptible to disease.
Author: 'Tacuina sanitatis'
©Educational use, non-commercial.

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Acknowledgment / Contribution

Kristina Vachadze and 'Domaine Kox'. More: https://repositorio-aberto.up.pt/bitstream/10216/157078/2/659369.pdf

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Agroforestry innovations: multifunctional olive systems

Promoting multifunctional olive systems for sustainable olive farming in the Mediterranean region.



Multifunctional olive systems combining olive trees with livestock (silvopastoral).
Author: LIVINGAGRO official website – https://www.livingagrolab.eu/
© Educational use, non-commercial.



Multifunctional Olive Systems combining olive trees with cover crops (silvoarable).
Author: LIVINGAGRO official website – https://www.livingagrolab.eu/
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/// Context ///

Agroforestry in the Mediterranean region represents a sustainable land-use system that integrates trees and shrubs into agricultural landscapes, combining agriculture and forestry practices to enhance biodiversity, improve soil health and optimize water usage. This approach is particularly significant in olive farming systems in the Mediterranean, where the climate is posing challenges such as soil erosion, water scarcity and desertification. Agroforestry systems, which combine trees with crops (silvoarable) or livestock (silvopastoral), can help address these issues by offering shade, reducing evaporation and improving soil fertility through the accumulation of organic matter. As climate change exacerbates environmental stresses, the adoption of agroforestry in the Mediterranean is gaining recognition for its potential to enhance ecological stability, improve agricultural productivity and support rural livelihoods.

The "LIVINGAGRO – Cross Border Living Laboratories for Agroforestry" project (ENI CBC Med Programme 2014-2020) was designed to tackle challenges of knowledge and technology transfer in Mediterranean agriculture and forestry systems. By adopting an open innovation approach, a Living-Lab on "Multifunctional Olive Systems" (MOS) has been established through partnership

Agroforestry in the Mediterranean is gaining recognition for its potential to enhance ecological stability, improve agricultural productivity and support rural livelihoods.

agreements between public and private entities, aimed at fostering collaboration among innovators and stakeholders. MOS refers to olive farming systems that deliver multiple benefits beyond the primary goal of olive oil and olive production. These systems strive to achieve a balanced relationship between agricultural productivity and environmental stewardship, incorporating sustainable farming practices and innovative solutions essential for addressing the challenges of olive farming in the Mediterranean. Innovations in this field were driven by the need to optimize land use, reduce environmental impact and enhance the viability of rural economies. This approach not only boosts olive production but also enhances the ecological, economic and social functions of the system by providing critical ecosystem services such as carbon sequestration, habitat preservation and water management, making it a model for sustainable agriculture in the Mediterranean and beyond.

Challenges of olive farming in the Mediterranean: the role of agroforestry and multifunctional olive systems.

Multifunctional olive systems not only boost olive production but also enhances the ecological, economic and social functions of the system, making it a model for sustainable agriculture.

/// Solution for a Resilient Future ///

LIVINGAGRO has compiled a variety of tested innovations that could greatly benefit olive farmers. Innovation in agriculture and forestry refers to “a new or improved idea that provide economic, social or environmental advantages in rural practices”.

Examples of tested innovations that could help transform olive groves into multifunctional olive systems include:

1 – Re-Using Traditional Practices in Agroforestry

- Livestock grazing in olive agroforestry systems

In Greece, olive groves cover ~ 700,000 hectares, with 124,311 dedicated to agroforestry. These systems incorporate understory crops such as vegetables, cereals or pasture, which are typically planted at densities of 50-100 per hectare. Traditional agroforestry integrates grazing animals or beekeeping, using both wild and cultivated plants. Scattered olive trees support herbaceous plants for grazing whereas trees planted in rows 10 m apart, support growing cereals and legumes. Sowing happens from mid-October to mid-November, with animals grazing on the stubble afterward. Olive agroforestry may increase the profitability and sustainability of the farm by the production of biomass and grains from the understory crops while positively affecting olive tree productivity. It improves orchard health and diversifies income through olive products, animal husbandry and crop cultivation.

- Olive tree, wild asparagus and free-range chicken polyculture

Historically, olive trees were cultivated alongside other crops and animals. Shifting to olive monocultures led to decreased soil fertility and increased erosion. To address this, green mulching is currently being employed. Cultivating wild asparagus (Asparagus acutifolius) in the shade of olive trees can maintain ground cover and provide extra income. Asparagus can be grown in tree rows or between them, though the latter may complicate equipment use and weed control. Additionally, raising chickens in the orchard helps control weeds and offers further income. Raising chickens in two cycles annually

Multifunctional olive systems: an integrated approach for sustainable olive farming.



Multifunctional Olive Systems combining olive trees with free-range chicken.
Author: Andrea Pisanelli | © Educational use, non-commercial.



Multifunctional Olive Systems combining olive trees with Asparagus.
Author: Adolfo Rosati
© Educational use, non-commercial.

Wild asparagus, a shade-tolerant perennial, can be grown alongside olive trees. It thrives under the same climatic conditions, making it a low-impact crop that can boost local incomes.

helps reduce weeds and fertilizers. This polyculture approach has proven environmentally beneficial, improving productivity and potentially increasing income compared to separate cultivation methods.

2 – Intercropping and preparing for Climate Change in olive groves

Intercropping enhances the sustainability of olive groves by increasing biodiversity and stabilizing the soil. This reduces the trees’ susceptibility to both biotic and abiotic stresses caused by climate change.

- Olive trees intercropped with cereals and legumes

Historically, olive groves in central Greece were intercropped with cereals and legumes. Recently, there’s renewed interest in combining olive production with crops such as durum wheat, barley, vetch and/or chickpeas. Chickpeas (Cicer arietinum L.) improve soil health by fixing nitrogen, reducing fertilizer costs; while vetch, grown during the rainy season, boosts soil fertility and prevents nitrogen loss. These practices support sustainable farming in Mediterranean climates and can increase farmers’ income by providing nutritious high-quality crops.

- Olive tree-avocado intercropping

Historically, olives were grown with other trees to naturally control pests, but this practice has declined, leading to an increase in pesticide use. By planting avocados between olive trees, biodiversity is restored, natural pest control is improved and farmers’ incomes rise due to higher avocado sales. In a Koroneiki olive grove, avocado trees are strategically planted in a 3.5 x 7 m layout, with Bacon avocados used for pollination. Ensuring a sufficient water supply is essential. This method enhances farm productivity, reduces erosion,

Chickpeas are cost-effective high-protein food and feed source. They improve soil fertility by fixing nitrogen, reducing need for fertilizers and protecting soil and water from nitrogen contamination.



Multifunctional Olive Systems combining olive trees with chickpeas.
Author: Anastasia Pantera | © Educational use, non-commercial.

boosts carbon storage, improves microclimates and creates better wildlife habitats, often leading to decreased pesticide use.

- Grafted olive trees resistant to the effects of climate change

The development of new, resilient olive cultivars will help expand cultivation areas, enhance resilience to climate change and improve the quality of olive oil and table olives.

Certain olive cultivars are more resilient to the effects of climate change and should be used as rootstocks for grafting with popular olive varieties to create new, stress-tolerant cultivars. Traditional varieties like Lefkolia, Arvanitolia and Leccino known for their resistance to salinity and drought, are ideal for this purpose. These rootstocks undergo thorough genetic, morphological and stress tolerance evaluations before grafting. The development of new, resilient olive cultivars will help expand cultivation areas in Greece, enhance climate change resilience and improve the quality of olive oil and table olives. This initiative will also provide valuable information for the olive industry both in Greece and internationally.

/// Always Moving Forward ///

Strategic steps with focus on continuous collaboration between all stakeholders, monitoring, evaluation, adaptive management and scaling successful models are needed in order to ensure the sustainability of olive farming in the Mediterranean.

By advancing the following steps, stakeholders can address future challenges, promote the adoption of multifunctional olive systems for sustainable land management and contribute to broader sustainable development goals in the region.

1 – Promote sustainable land management

- Encourage the adoption of agroecological practices that enhance biodiversity, soil health and water management.
- Implement integrated pest management strategies to reduce reliance on chemical inputs and promote ecological balance.
- Promote techniques such as terracing, mulching and efficient irrigation to conserve soil and water resources.
- Promote land-use planning that integrates agroforestry with other rural development activities such as tourism and conservation.

2 – Strengthen stakeholder collaboration

- Create regular forums for dialogue among farmers, government agencies, researchers, NGOs and private sector entities to foster collaboration and share best practices.
- Create networks for farmers to share experiences, challenges and solutions related to adopting best practices.
- Form partnerships between academic institutions, international organizations and local communities to conduct studies on the long-term impacts of these innovations.

Strategic steps to ensure the long-term success and sustainability of multifunctional olive systems in the Mediterranean.

3 – Implement continuous monitoring and evaluation

- Establish comprehensive monitoring systems to track the environmental, social, and economic impacts of olive farming practices.
- Conduct regular assessments to evaluate the effectiveness of implemented strategies and adapt them based on findings.
- Promote transparent data sharing among stakeholders to facilitate informed decision-making.

4 – Promote adaptive management practices

- Design flexible management plans that can be adjusted based on monitoring results and changing conditions.
- Integrate climate resilience strategies into management plans to address the impacts of climate change on olive farming.



Multifunctional Olive Systems combining olive trees with a mixture of barley and common vetch.
Author: Kostas Mantzanas | © Educational use, non-commercial.



Multifunctional Olive Systems combining olive trees with Avocado.
Author: Lisa Radinovsky | © Educational use, non-commercial.

5 – Scale successful models

- Identify successful models from pilot projects and develop strategies for scaling them up across broader regions.
- Adapt and replicate successful innovations in similar agroecosystems.

6 – Support policy and regulatory frameworks

- Work with policymakers to create supportive regulatory frameworks and incentives for sustainable olive farming.
- Develop and enforce standards for sustainable practices and certification schemes to ensure compliance and promote market access.

7 – Foster research and innovation

- Invest in research to develop climate-resilient cultivars, new technologies and practices that enhance the sustainability of olive farming.
- Create innovation hubs where researchers, farmers, and entrepreneurs can collaborate on developing and testing new innovations.

Cooperation allowed to increase the project's operational spin-offs and transferability of the system and methodologies.

The VISTOCK System was developed to manage beef cattle grazing in a rational and sustainable way.

8 – Promote market access and value addition

- Strengthen the value chain by supporting smallholders in accessing markets, adding value to products and improving marketing strategies.
- Promote fair trade practices to ensure that farmers receive fair compensation for their products.
- Develop eco-tourism initiatives that showcase agroforestry systems, providing additional income streams for rural communities.

9 – Improve awareness, capacity building and education

- Conduct campaigns to raise awareness about the importance of multifunctional olive systems and their benefits.
- Develop training programs that cover all aspects of agroforestry, intercropping and polyculture practices.
- Provide training and resources to farmers and other stakeholders to adopt and scale successful practices.
- Develop educational programs for schools and communities to foster a culture of sustainability from a young age.



Multifunctional Olive Systems combining olive trees with vetch as cover crops.
Author: LIVINGAGRO official website – https://www.livingagrolab.eu/
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Authors: Dany Ghosn and Ilektra Remoundou – CIHEAM-MAICh | **Partners:** CIHEAM – MAICH – Mediterranean Agronomic Institute of Chania

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Type of solution: Management Sector: Agriculture, Agroforestry, Forestry

Good practice(s): Water management, Soil management, Management alternatives, Ecosystems services, Community engagement, Protection against biotic and abiotic hazards

Multifunctional Olive Systems: a cutting-edge approach in agroforestry

Promoting multifunctional olive systems for sustainable olive farming in the Mediterranean region.



Multifunctional Olive Systems in Italy combining olive trees with livestock (silvopastoral).
Author: Andrea Pisanelli | © Educational use, non-commercial.



Multifunctional Olive Systems in Central Portugal combining olive trees with cover crops (silvoarable).
Author: Joana Amaral Paulo | © Educational use, non-commercial.

/// Context ///

Multifunctional olive systems (MOS) represent a cutting-edge approach in agroforestry that integrates olive cultivation with other land uses to maximize ecological, economic and social benefits. This approach is particularly significant in the Mediterranean, where the climate is posing challenges such as soil erosion, water scarcity and desertification. By combining olive trees with other crops (silvoarable) or livestock (silvopastoral), this approach can help address these issues effectively by offering shade, reducing evaporation and improving soil fertility through the accumulation of organic matter, thereby fostering resilient landscapes that support sustainable agriculture in the Mediterranean and beyond.

Through the Multifunctional Olive Systems initiative, the LIVINGAGRO project was designed to address knowledge and technology transfer in Mediterranean agriculture and forestry. It established collaboration between public and private entities to innovate and implement sustainable farming practices in olive farming. Innovations (introduction of new or renewed ideas: a novel change that proves successful in practice) were driven by the need to optimize land use, reduce environmental impact and enhance the viability of rural economies.

/// Solution for a Resilient Future ///

Examples of tested innovations that could help transform olive groves into multifunctional olive systems include:

1 – Re-Using Traditional Practices in Agroforestry

- Livestock grazing in olive agroforestry systems

In Greece, olive groves cover ~ 700,000 hectares, with 124,311 used for agroforestry. These systems combine olive trees with understory crops like vegetables, cereals or pasture. Traditional practices also include grazing animals or beekeeping. Olive trees are either scattered to support grazing herbaceous plants or planted in rows 10 m apart for growing cereals and legumes. Sowing occurs from October to November, with grazing on stubble afterward. Olive agroforestry may increase the profitability and sustainability of the farm by the production of biomass and grains from the understory crops while positively affecting olive tree productivity. It improves orchard health and diversifies income through animal husbandry and crop cultivation.

- Olive tree, wild asparagus and free-range chicken polyculture

Historically, olive trees were grown with other crops and animals. Shifting to olive monocultures led to reduced soil fertility and increased erosion. To counter this, green mulching is currently being used. Cultivating wild asparagus in the shade of olive trees helps maintain ground cover and provides additional income. Asparagus can be grown in tree rows or between them. Additionally, raising chickens in the orchard controls weeds and offers extra income. This polyculture approach improves environmental health, productivity and income compared to separate cultivation methods.

2 – Intercropping and preparing for Climate Change in olive groves

- Olive trees intercropped with cereals and legumes

Historically, olive groves in Greece were intercropped with cereals and legumes. Recently, there's renewed interest in combining olive production with crops like durum wheat, barley, vetch and/or chickpeas. Chickpeas enhance soil health by fixing nitrogen, reducing fertilizer use, while vetch improves soil fertility and prevents nitrogen loss. These practices not only support farming sustainability but also boost farmers' income with nutritious, high-quality crops.

- Olive tree-avocado intercropping

Historically, olives were grown alongside other trees for natural pest control, but this practice declined, increasing pesticide use. Planting avocados between olive trees restores biodiversity, enhances natural pest control and boosts farmers' incomes from avocado sales. In Koroneiki olive groves, avocados are planted in a 3.5 x 7 m layout with Bacon avocados for pollination. Ensuring a sufficient water supply is essential. This approach improves productivity, reduces erosion, boosts carbon storage, enhances microclimates and creates better wildlife habitats, often leading to reduced pesticide use.

- Grafted olive trees resistant to the effects of climate change

Certain olive cultivars, such as Lefkolia, Arvanitolia and Leccino, are more resistant to salinity and drought. These cultivars should be used as rootstocks for grafting with popular olive varieties to create new, stress-tolerant cultivars. Thorough evaluations of genetic, morphological and stress tolerance traits should be conducted before grafting. This approach improves resilience to climate change and enhance the quality of olive oil and table olives.



Multifunctional Olive Systems in Italy combining olive trees with Asparagus.
Author: Adolfo Rosati | © Educational use, non-commercial.



Multifunctional Olive Systems in South Portugal combining olive trees with cereals.
Author: Joana Amaral Paulo | © Educational use, non-commercial.

/// Always Moving Forward ///

Several strategic steps are needed in order to ensure the sustainability of olive farming in the Mediterranean:

- Promote sustainable land management: Encourage agroecological practices and integrate land use with agroforestry and rural development.
- Strengthen stakeholder collaboration: Establish regular forums for dialogue among farmers, governments, researchers, NGOs and the private sector.
- Implement continuous monitoring and evaluation: Develop monitoring systems to track impacts and share data for informed decision-making.
- Promote adaptive management practices: Create flexible management plans that can adjust to monitoring results and climate impacts.
- Scale successful models: Expand successful pilot projects to similar agroecosystems.
- Support policy and regulatory frameworks: Work with policymakers to create supportive regulations, standards and incentives for sustainability.
- Foster research and innovation: Invest in research and create hubs for developing climate-resilient technologies.
- Promote market access and value addition: Support smallholders in market access, value addition, fair trade and agro-tourism initiatives.
- Improve awareness, capacity building and education: Conduct awareness campaigns, develop training programs and provide resources to support best practices.

Further information

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ResAlliance

Legume-based seed mixtures for pasture improvement in Mediterranean agroforestry systems

Improved soil and pasture management boosts the resilience of grazed woodlands and multifunctional olive systems.



Soil managing of a multifunctional olive grove: natural grassing (right) vs artificial grassing with fall seeding of an innovative legume-based mixture (left).
Author: Pasquale Arca | © CNR



Figure 2. Cattle grazing in an official "forest": over-thinned Pinus sylvestris. Grazing can be better managed to allow forests successful silvopastoralism.
Author: Vasilios Papanastasis (HAN) | © CC-BY

/// Context ///

In agroforestry systems, such as Grazed woodlands (GW) and Multifunctional olive systems (MOS), the use of appropriate legume-based seed mixtures, adapted to climate and soil site-specific conditions, can improve long-term pasture productivity and forage quality, raise sustainability and the quality of olive production, leading in both contexts, to higher incomes for farmers and better environmental performances. The soil benefits from a greater amount of crop residues, increasing its carbon sequestration and overall fertility. Moreover, the correct management of permanent legume-based mixtures can facilitate the transition to organic farming systems both for animal products and olive production.

Unfortunately, the current seed market for pasture species suitable for Mediterranean climates does not guarantee the required seed availability, as it is constrained by the commercial choices of producer countries (especially Australia). Thus, early investigation of seed availability from seed companies or producers is desirable to have time to design site-specific and well adapted legume-based mixtures.

Two herbaceous seed mixtures were developed and registered through a collaborative private-public research agreement, within the LIVINGAGRO cross-border cooperation project (ENI CBC MED), to provide market varieties adapted to local conditions.

The beneficial effects of using such legume-based cover crops can be summarised in:

- Improvement of the sustainability of the olive grove system.

Grazed woodlands and Multifunctional Olive Systems: two sides of the same coin in the Mediterranean basin.

The use of legume-based mixtures well adapted to soil and climate conditions can improve pasture productivity, forage and of olive quality, raising productivity and sustainability.

- Economic benefits due to cost reduction for tillage, fertilisers, herbicides, etc.
- Lower environmental impact (less use of chemicals, lower greenhouse gas emissions).
- Improved soil fertility (increased carbon stock and sequestration in the soil due to increased crop residues and reduced tillage).
- Economic benefits due to the higher self-sufficiency i.e. increased pasture yield, improved quality of forage.
- Sustainable weed control.
- Improved accessibility of the olive grove along the year, especially during olives harvesting (autumn and winter).
- Potential improvement of the quality of olive and olive oil production, granting the possibility to sell organic products (olives and olive oil).
- Greater integration between olive farming and animal breeding (sheep, horses, geese, etc.).

The soil benefits from a greater amount of crop residues, increasing its C sequestration and overall fertility.

/// Solution for a Resilient Future ///

The selection of appropriate plant species and the adoption of correct management practices is very important if the efficiency and ecosystem service provision from agroforestry systems is to be maximised. In this context, a research collaborative agreement was signed between the Agency FORESTAS, the private seed company FERTIPRADO, the national research institute CNR-ISPAAM, with the collaboration of the Lebanese Agricultural Research Institute (LARI). The general aim was to set up and register innovative legume-based seed mixtures to be used as cover crops adapted to Mediterranean conditions in grazed woodlands or olive groves for agroforestry purposes. The specific objectives of the cooperation were:

- Set up innovative seed mixtures made mainly of materials of local origin adapted to site conditions and suitable for GW and MOS.
- To carry out field trials in order to evaluate the performance of the seed mixtures and the effects on the sward.
- To register the seed mixtures as new products resulting from the project activities in order to enter the market.

Experimental field trials were established and carried out within private farms in agroforestry systems of Sardinia and Lebanon. In the grazed woodland trials, three treatments were compared:

1. Improved pasture with commercial seed mixture.
2. Improved pasture with innovative legume-based seed mixture.
3. Unimproved native pasture.

In the olive grove system, four treatments were compared:

1. Cover cropping with commercial seed mixture.
2. Cover cropping with innovative legume-based seed mixture.
3. Natural cover cropping.
4. Traditional management with soil tillage.



Semi-natural pre-flowering pasture made in Nurra (Sardinia) by sowing from scratch innovative mixtures based mainly on self-seeding annual legumes.
Author: Pasquale Arca | © CNR

The mixture for multifunctional olive systems is a combination of four well adapted site-specific annual self-reseeding species: one grass and three legume species.



Different levels of spring herbaceous cover under canopy and outside canopy of an olive grove in Nurra (Sardinia) managed with cover crops.
Author: Pasquale Arca | © CNR

Improving the sustainability of agroforestry systems, the seeds mixtures solution!

In Sardinia the observations were carried out by CNR-ISPAAM in collaboration with the specialist in olive cultivation of the University of Sassari, with the main goal of collecting useful indications on the different types of management in MOS under Mediterranean rainfed conditions, by analysing the effects of the innovative cover crops on olive plants physiology and fruit productions.

Mixtures for multifunctional olive systems

Grass and legume varieties in the site-specific seed mixtures were selected primarily on the basis of soil characteristics (pH, soil depth and soil water retention) and climatic conditions (rainfall distribution and duration of drought periods). In the seed mixture, the use of annual self-reseeding species and varieties rather than perennials is suggested to avoid water competition with olive trees during the dry period (late spring and summer). The selection of species therefore took into account their vegetative cycle, so that the competition for water with the olive grove is limited. In fact, especially as a consequence of climate change, the risk of spring droughts could be a problem for seed production and water competition with olive plants.

The mixture is based mainly on legume varieties, which are able to improve soil nitrogen content and the availability of nutrients for the olive grove. Moreover, the dry plant residuals represent a mulching layer able to prevent weed diffusion, reduce water losses from the soil during summer and prevent soil erosion.

The mixture for MOS is a combination of four well adapted site-specific annual self-reseeding pasture species: one grass and three legume species. They should be sown after minimum tillage or as sod seeding in early autumn.

The site-specific mixture for wooded pastures is a combination of six well adapted site-specific species: three annual self-reseeding legumes, two grasses and one perennial forb/herb.



Minimal tillage on a natural arboreal pasture required for reseeding of forage mixtures based on self-seeding annual legumes.
Author: Pasquale Arca | © CNR

The secondary metabolites of the forb have been reported to demonstrate some biological activities such as antioxidant, anti-inflammatory, antiparasitic, antihepatotoxic.

Mixtures for grazed woodlands

In GW, sowing legume-based annual self-reseeding pastures improves soil nitrogen content and should be associated with minimum tillage or sod seeding. The innovative site-specific mixture for wooded pastures is a combination of six well adapted site-specific species: three annual self-reseeding legumes, two grasses (an annual self-reseeding + a perennial species) and one perennial forb/herb. The selection of species considers their functional group and vegetative cycle, so that there is a low competition for water with the trees.

An innovative important aspect is the inclusion of a forb component i.e. chicory. The secondary metabolites (flavonoids, tannins, and coumarins) found in chicory have been reported to demonstrate some biological activities such as antioxidant, anticancer, anti-inflammatory, antiparasitic, antihepatotoxic, which impact positive health effect on livestock. Moreover, improve the performance of lactating animals by increasing partitioning of N toward milk synthesis, reducing CH4 production and enhancing immunity. Another key component is the inclusion of a summer dormant perennial grasses i.e. cocksfoot able to persist under long summer drought.

/// Always Moving Forward ///

The solution presented hereby represents an attempt to valorise the decade long commitment of the National Research Council (CNR ISPAAM) in Sardinia (Italy) in the study of local forage varieties, as pure stands or mixtures, for pasture improvement or restoration purposes. The project LIVINGAGRO provided the opportunity to test such mixtures in Lebanon and Sardinia and liaise with a major seed company operating in the international market through a public-private agreement, and to disseminate the best practice among the two Living Labs of the LivingAgro project in four collaborating countries (Italy, Greece, Jordan and Lebanon). The practice received great interest in workshops, brokerage events and field visits, which allowed direct interactions among scientists, farmers and private partners in real case scenarios.

As seed availability is currently constrained by the commercial choices, it is of utmost importance to encourage and support local seed production of Mediterranean species and varieties suited to the sites of interest, in order to reduce supply dependence on foreign markets. A fundamental part is site analysis and soil and climatic data collection, to identify the appropriate species and varieties. Continuous and sound research programmes carried out by public or private institutes for selecting local ecotypes is essential to provide the best available plant material, considering all adaptation traits. Studies on production limitations connected to plant and seed traits are also fundamental. Involvement of all the stakeholders in the seed production, commercialisation and consumption value chains is desirable. One approach can be knowledge and best practice sharing among Living laboratories for agroforestry systems.

Moreover, mixtures need a correct seasonal management to guarantee a long-term sword in the field. Species selection is not sufficient to ensure the benefits of the innovative mixture. Once seeded, it is essential to adopt appropriate agronomic management techniques. For example, for grazed woodlands, it is important to adopt plans and pasture management techniques which may involve rotational grazing, avoiding

Towards self-sufficiency in the production of indigenous pasture mixtures.



Soil tillage and seeding of a self-seeding annual legume seed mixture required for grassing an olive grove.
Author: Pasquale Arca | © CNR

There are severe limitations to the supply of seeds of pasture species suitable for marginal Mediterranean and agroforestry environments.



Biomass sampling of a permanent arboreal pasture undergoing improvement by reseeding self-seeding annual forage species.
Author: Pasquale Arca | © CNR

Planting of a semi-natural pasture by autumn seeding of a legume-based mixture in a silvopasture system in central-northern Sardinia.
Author: Pasquale Arca | © CNR

grazing during the flowering of self-reseeding species in the spring season, managing weeds (mowing/chopping) and phosphorus fertilisation.

In some sites, such as protected areas of high environmental value, or particularly fragile sites, it may be recommended to carry out seed collections from donor sites to restore degraded areas and pastures. An alternative system to improve the availability of native seed could be the use of Hand-Held Seed Stripper (HHSS). This tool was developed for use in rugged terrain, ecologically sensitive areas, nursery and small plots. HHSS harvests a wide variety of native grasses and legume seeds with low environmental impact. It is light and easy to use and it is carried on a shoulder strap harness. It is powered by a low maintenance, fuel-efficient, 2-cycle gas engine. In easier conditions, i.e. flat soils with little stoniness, it is possible to use new mechanical seed strippers, which allow to significantly increase the efficiency and seed collection capacity.



When well adapted species are not present in the seed market, make sure to directly collect native species from donor areas using the seed strippers.

Very often the areas of intervention are of high environmental interest and are subject to management constraints which make harvesting with seed strippers an almost obligatory route.

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Mixtures for MOS: Lolium rigidum 13.9% Medicago polymorpha 23.1% Ornithopus sativus 27.8% Trifolium subterraneum spp subterraneum 27.8%.

Mixtures for grazed woodlands: Cichorium intybus 18.5% Dactylis glomerata 18.5% Lolium rigidum 9.3% Medicago polymorpha 23.1% Trifolium subterraneum spp subterraneum 11.6%.

Authors: Claudio Antonio Porqueddu, Sara Maltoni, Mauro Forteschi
Partners: FoReSTAS – Agenzia forestale regionale per lo sviluppo del territorio e l'ambiente della Sardegna

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ResAlliance

Stone pine grafting with alternative rootstock species and grafting approaches: an alternative to increase the potential production area of stone pine nuts

Results from a 12-year experiment contributing to a more versatile land use and with multiple benefits in the domain of Stone and Aleppo pines in Os de Balaguer (Lleida, Spain).



Aspect of the plantation in 2012.
Author: AGS-CTFC | © CC BY-NC-ND 4.0



Image of a successfully grafted tree.
Author: AGS-CTFC | © CC BY-NC-ND 4.0

/// Context ///

The Mediterranean Stone Pine (*Pinus pinea*) is a species of high productive and ecological interest in the Mediterranean region, particularly known for its highly prized edible nut. The grafting technique makes it possible to anticipate and significantly increase nut production, resulting in a growing interest in this species as a forest fruit tree. In addition, grafting onto Aleppo pine (Pinus halepensis) rootstocks significantly increases the potential production area of stone pine nuts.

We describe the process of design, implementation, maintenance, and production results of a stone pine plantation installed at the beginning of 2012 with a triple objective:

- Nut production.
- Prevent land abandonment and maintain a mosaic agroforestry landscape.
- To generate research and knowledge transfer on the use of different rootstocks (Aleppo pine – *Pinus halepensis* vs. Mediterranean Stone Pine – *Pinus pinea*) and grafting approaches (nursery vs. field grafting vs. no grafting).

This plantation was established by the Forest Science and Technology Centre of Catalonia (CTFC) on private land, as part of the AECI-PCI project "Production and management techniques of stone pine (*Pinus pinea*) for early pine production: plantations planted as an alternative for the restoration of degraded areas and the generation of income in rural communities". In recent years, monitoring has been carried out under the MasPineNut project "Making sustainable the stone pine production by its management as nut tree" (2020-2024), led by IRTA and CTFC.

/// Solution for a Resilient Future ///

The Mediterranean stone pine is characterised by its multifunctionality, both productive (highly valued pine nut, timber), ecological (restoration of sandy soils) and social – a species characteristic of the Mediterranean landscape, with a particular conformation, with an umbrella-shaped crown.

The aim of this experimental and demonstration plantation, which covers almost one hectare and was planted in Os de Balaguer (Lleida province) in the winter of 2011-2012, is threefold:

1. Production of pine nuts: to produce a nut with a remarkably high market price, averaging 60€/kg between 2020 and 2023 (DACC, 2024).
2. Preventing the abandonment of a small agricultural plot and maintaining a mosaic landscape.
3. Experimental: to generate knowledge on the effect of grafting (evaluation of nursery grafted trees, field grafted trees and non-grafted trees) and on the use of rootstocks of different species (Mediterranean stone pine and Aleppo pine) on survival and cone production.

The number of experimental trees is:

- Stone pine rootstocks (70) vs Aleppo pine rootstocks (70).
- Nursery grafted (44) vs field grafted (68) vs not grafted (18).

In the different treatments, three complete randomised blocks were distributed. A total of 140 trees were planted in a 5 x 5 frame.

Soil preparation consisted of deep subsoiling (50 cm) and manual opening of pits (30 x 30 x 30 cm). At the time of planting, black polyethylene mulch (100 x 100 cm) was placed on each tree to prevent competition from spontaneous vegetation and individual 60 cm black mesh protectors to prevent damage from fauna. The perimeter of the field was protected by a 150 cm high fence.

	Kernel biomass per tree, 2021 (g)	Equivalent gross income, 2021 (€/ha)*	Kernel biomass per tree, 2022 (g)	Equivalent gross income, 2022 (€/ha)*
P. halepensis, field grafting	423.9	1,017	67.8	163
P. halepensis, nursery grafting	511.8	1,228	48.5	116
P. pinea, field grafting	39.9	96	26.0	62
P. pinea, nursery grafting	114.4	275	25.3	61
P. pinea, not grafted	2.6	6	7.6	18

* Based on 400 trees/ha with this treatment, and the average market reference price of 60 €/kg.

Nursery grafting was carried out in April 2011 and field grafting in April 2012.

Maintenance consisted of low pruning in 2012, 2014 and 2020 to prevent rootstock branches from dominating the canopy, annual or bi-annual pruning and cutting of Aleppo pines where grafting was unsatisfactory and replacing them with new stone pines (20). Finally, in 2022 and 2023, *Leptoglossus occidentalis* (western conifer seed bug) was treated with deltamethrin (40 ml/100 l of water; application of 150-180 l), applied with a sprayer and elevator.

The variables measured, with varying periodicity, are:

- Survival and vegetative state.
- Basal diameter.
- Total height.
- Number of cones of different ages, in summer and winter (2021-23).
- Pine nut production and kernel:cone ratio (2021-23).

The main results of the plantation are as follows:

- Mortality was 5% in Aleppo pine rootstocks and 13% in stone pine rootstocks. No differences were observed between trees grafted in the nursery or in the field.
- Productivity, both in terms of cones 2021-23 and biomass, shows a yield superiority of trees with Aleppo pine rootstock. In 2021, the income per hectare of pines grafted with Aleppo pine rootstock exceeded 1,000 €/ha, a very promising figure considering the age of the plantation (11 years).
- The non-grafted pine trees are clearly the least productive, with only 17% of the trees starting to produce cones.
- Finally, the kernel:cone ratio was 5.0% in healthy cones and 3.6% in cones damaged by *Leptoglossus occidentalis*.



Panoramic image of the stone pine plantation in Os de Balaguer.
Author: GFPA-CTFC | © CC BY-NC-ND 4.0



Plantation monitoring measures during 2023.
Author: GFPA-CTFC | © CC BY-NC-ND 4.0

/// Always Moving Forward ///

Wild animals feeding and domestic grazing on acorns can slightly alter the values presented above. Estimates of acorn availability can be improved and made more robust by continuing the acorn inventory for several years in a row. Linking acorn availability values with meteorological data, forest stands and soil characteristics, could provide relevant information on acorn availability as a function of the above variables, and contribute to new silvicultural approaches for multipurpose management of Pyrenean oak stands.

Acorn harvesting is essentially manual, which makes the process time consuming and costly, and there is a shortage of labour in the interior regions. Mechanical harvesting technology is underdeveloped, although some attempts have been made to adapt equipment used for other crops such as olives and chestnuts. In the future, equipment and technology may be developed or harvesting methods improved to speed up the process and make harvesting more economical.

By investing in research and continuing to collect data, it will be possible to improve the estimates of acorn prediction models, as well as improving forestry models in terms of acorn availability.

The acorn value chain needs to be improved through the development of food products and the associated marketing of products containing acorns.

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Type of solution: Management, Technology
Sector: Agriculture, Agroforestry, Forestry
Good practice(s): Management alternatives, Community engagement

Integrating Agrivoltaics and Agroforestry for resilient Mediterranean landscapes

Synergistic approaches to enhance yields and maximise co-benefits by incorporating agroforestry and agrivoltaics in the Mediterranean.



Solar grazing – a practice that is becoming more widespread in agrivoltaics systems.
Author: Source: solargrazing.org | © Educational use, non-commercial.



...vs silvopastoral agroforestry systems, which have been common for millenia!
Author: Agriland.ie | © Educational use, non-commercial.

/// Context ///

The Mediterranean region faces complex challenges at the intersection of energy, agriculture, and environmental sustainability. As the demand for renewable energy sources like solar power continues to grow, land use conflicts with traditional agricultural practices are becoming more pronounced. However, integrating agrivoltaic systems with agroforestry offers a promising solution to these challenges. Agrivoltaics involves placing solar photovoltaic (PV) panels alongside agricultural production, while agroforestry combines crops, trees, and livestock within the same land area.

Key findings indicate that this integration can enhance productivity while providing renewable energy. For instance, the shade from solar panels can improve microclimate conditions, reduce water stress on crops, and increase biodiversity – as agroforestry systems do. While crop yields may fluctuate, farmers could expect an overall increase in land productivity by selling the energy generated by the solar panels.

Therefore, to maximise these benefits, farmers may consider adopting agrivoltaic systems alongside agroforestry practices. For example, farmers can grow shade-tolerant crops or raise livestock under the solar panels and trees, optimising land use and creating a more resilient farming system. Implementing these practices can be cost-effective, as the initial investment in solar technology can be offset by the savings on energy costs. Additionally, by participating in renewable energy programs, farmers may access financial incentives or subsidies that further enhance profitability.

With careful planning and support, this synergistic model can transform the agricultural landscape, making it more resilient to the challenges of climate change and resource scarcity. Drawing inspiration from the six indicators of sustainable development listed in the EU Taxonomy Regulation, as illustrated in the 'Brno Agroforestry Declaration', this factsheet highlights how combining agroforestry with agrivoltaics systems is a win-win solution.

Harnessing synergies for sustainable land use in the Mediterranean.

Integrating agrivoltaic systems in Mediterranean olive groves could increase global PV capacity by 2.5% and generate 1.8% of Mediterranean countries electricity demand (Fernandez-Solas et al., 2023).

We could produce all of France's electricity (including that of nuclear power plants) with only 300,000 ha of agrivoltaics, or less than 1% of cultivated land (pers. comm., Christian Dupraz, EURAF).

/// Solution for a Resilient Future ///

The integration of agrivoltaics and agroforestry in Mediterranean landscapes offers a range of benefits that can be categorised into several key areas:

- Climate Change Mitigation

The implementation of agrivoltaic systems significantly contributes to climate change mitigation by generating clean, renewable energy while simultaneously enhancing agricultural productivity. The solar PV panels installed within agroforestry systems not only reduce reliance on fossil fuels but also help in carbon sequestration through the introduction of woody vegetation. Studies indicate that integrating bifacial PV modules with crops can optimise land use and enhance productivity, leading to a maximum Land Efficiency Ratio (LER) of 171% when modules are tilted appropriately (Mouhib et al., 2024).

- Climate Change Adaptation

Agrivoltaics and agroforestry together create a favourable microclimate that can help mitigate the impacts of climate change. The combination of solar panels, crops, and trees can lower air temperatures and increase humidity, reducing heat stress and water demand for agricultural components. For instance, in an apple orchard with solar panels, air temperature was reduced by 3.8 °C, while relative humidity increased by 14% (Juillion et al., 2022). These adaptations can enhance crop resilience to extreme weather conditions, ultimately leading to more stable yields in the face of climate shocks.

- Sustainable Water Resources

The integration of agrivoltaics can also lead to improved water management practices. The shading provided by solar panels can reduce evaporation rates and enhance soil moisture retention, which is crucial in the water-scarce Mediterranean region. Research shows that agrivoltaics systems can alleviate water stress on crops by up to 63% (Hendarti et al., 2024).

- Soil, Water, and Atmospheric Pollution

The introduction of diverse vegetation in agroforestry systems can enhance soil structure and fertility, leading to healthier ecosystems. Furthermore, improved ventilation (possibly caused by the microclimate of such systems) under PV panels can reduce pest pressures, potentially decreasing the reliance on pesticides (Toledo and Scognamiglio, 2021).



Orchard agrivoltaics is already gaining traction is central Europe. This is an organic orchard in Gelsdorf, western Germany.
Author: Martin Meissner | © Educational use, non-commercial.

- Protection of Biodiversity and Ecosystems

The tree component of combined agrivoltaics-agroforestry systems enhances biodiversity by introducing various species, such as flowering trees, which improve ecosystem services such as pollination and carbon sequestration. By fostering a diverse range of species, these systems contribute to the overall health of Mediterranean ecosystems, promoting resilience against environmental changes.

- The Circular Economy

Integrating agrivoltaics into agricultural practices aligns with the principles of the circular economy by maximising resource efficiency and minimising waste. The dual use of land for energy and food production allows for a more sustainable approach to resource management. Yet, what remains to be seen is how solar panels will be used once they reach their end of life.

- Rural socio-economics

The adoption of agrivoltaics and agroforestry systems can generate significant socio-economic benefits for rural communities. Additional income streams (e.g. through energy production – as well as timber derived from agroforestry), farmers can diversify their revenue sources and enhance their financial stability. It was estimated that if agrivoltaics were installed on just 1% of olive groves in the Mediterranean, it could create approximately 560,000 jobs (Fernandez-Solas et al., 2023). This potential for job creation supports rural development and contributes to the vitality of local economies.

- Skills, Policies, and Generation Renewal

Integrating agrivoltaics and agroforestry for multifunctional landscapes.

In Greece, grazing is officially applied in 7 PV parks. Latest observations and measurements showed no interference of grazing to the amounts of energy produced (pers. comm. Anastasia Pantera, AUA).



If installed on 1 % of the olive surface area, agrivoltaics with trees could create around 560,000 jobs (Fernandez-Solas et al., 2023).

The research centre VUKOZ is one of the pioneers in testing agroforestry-agrivoltaics combined systems.
Author: VUKOZ (Silva Tarouca Research Institute for Landscape and Ornamental Gardening)
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To fully realise the benefits of agrivoltaics and agroforestry, it is essential to develop supportive policies and programs that encourage knowledge sharing and skill development among farmers and foresters. Training programs focusing on the implementation and management of these integrated systems can empower the next generation of farmers to adopt innovative practices. Some EU Member States already use CAP funds to incentivise agrivoltaics on farm land – the majority of EU Member States do offer support for the establishment and management of agroforestry systems. Why not supporting both at the same time?

/// Always Moving Forward ///

To drive the widespread adoption of integrated agrivoltaics-agroforestry systems in the Mediterranean region, researchers, policymakers, and industry stakeholders should intensify their efforts in a couple of areas, such as:

- Addressing Regulatory Barriers

One of the primary challenges is addressing regulatory and policy barriers, such as land use zoning and incentive schemes. These barriers must be navigated to enable the complementary integration of renewable energy on agricultural land.

- Developing Decision Support Tools and Guidelines

To facilitate the implementation of these integrated systems, developing decision support tools and guidelines is essential. These resources can help landowners and farmers design and implement agrivoltaic-agroforestry systems tailored to their local conditions and needs (Bellone et al., 2024). Tools developed by initiatives like the HyPErFarm project provide valuable insights and practical guidance for effective system integration.

- Exploring Innovative Business Models and Marketing Strategies

Exploring innovative business models and financing mechanisms is crucial to support the upfront investments required for integrated agrivoltaic systems.

Scaling up integrated agrivoltaic-agroforestry systems.

The potential for Agri-PV in the EU is immense: if Agri-PV were deployed on only 1% of Europe's arable land, its technical capacity would be over 700 GW (pers. comm., Solar Power Europe).

Creative financing options, such as public-private partnerships and community-based funding, can help alleviate financial barriers for farmers. Additionally, marketing strategies that highlight the dual benefits of renewable energy generation and sustainable food production can attract consumers and investors alike.

- Promoting Research and Innovation

Essential to address knowledge gaps and maximise the synergies between energy and food production. Recent studies indicate that the presence of trees or solar panels on agricultural land creates distinct light environments for understory crops (Rosati et al., 2023). Continued research can help optimize these systems and inform best practices for implementation.

- Fostering Knowledge-Sharing and Capacity-Building

Fostering knowledge-sharing and capacity-building initiatives is critical for disseminating best practices and lessons learned from pilot projects and demonstration sites (Gomez-Casanovas et al., 2016; Solar Power Europe 'Good practice guide' – Agrivoltaics). By creating platforms for collaboration and information exchange, stakeholders can enhance the collective understanding of agrivoltaics-agroforestry systems and their benefits.



What about vitiforestry with solar panels?
Author: Joe P – stock.adobe.com | © Educational use, non-commercial.

Agrivoltaics and agroforestry together may contribute to accelerating the path towards climate-smart agriculture in the Mediterranean: 0.1 hectares of solar panels and 0.1 hectares of trees on a 1-hectare plot could reduce emissions by 20-30 metric tons of CO2 per year while also producing renewable electricity. If half of the agricultural land in the Mediterranean (1.5 million hectares) were converted to agrivoltaics-agroforestry systems with 10% solar panels and 10% trees cover, it could potentially reduce CO2 emissions by 3 to 4.5 million metric tons per year—equivalent to the annual emissions of 6.5 to 9.8 million passenger vehicles.

As the Mediterranean region grapples with the challenges of climate change, land use conflicts, and the need for sustainable development, the integration of agrivoltaics and agroforestry offers a promising pathway to create multifunctional, resilient, and productive landscapes. By harnessing the synergies between renewable energy, food production, and forestry, these innovative approaches can help the region transition towards a more sustainable and prosperous future.

Several factors showed a positive effect on seed cone production in Aleppo pine natural forest growing in North Africa.

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Agroforestry and climate resilience: Carbon sequestration in an olive grove in northern Tunisia

Agroforestry plays a significant role in carbon sequestration by integrating trees and shrubs into agricultural systems.



A farmer who practices permaculture waters crops in a field at Cap Negro, Bizerte, in northern Tunisia.
Author: Lilia Blaise | © Lilia Blaise



Cultivation of wheat in an olive field in northern Tunisia.
Author: Samir Ghannem | © Samir Ghannem

/// Context ///

Sustainable agriculture appears to be a key response to environmental and economic challenges. However, creating a carbon sink is a better way to protect against global warming. The convergence of agroforestry and climate resilience highlights the remarkable ability of this practice to sequester carbon in sustainable agricultural systems. Thus, agroforestry, the deliberate integration of trees into crops, is an effective way to capture carbon dioxide from the atmosphere, helping to mitigate the effects of climate change. In addition, olive cultivation, mainly practiced in Mediterranean regions, also offers interesting opportunities in terms of carbon sequestration. Olive groves can play a crucial role in capturing carbon from the atmosphere through their ability to store carbon in soil, wood and plant residues. In addition to contributing to the fight against climate change, olive groves promote the preservation of biodiversity and traditional landscapes. The introduction of sustainable agricultural practices in the cultivation of olive trees, such as agroforestry by combining for example shade trees, can not only increase carbon sequestration, but also improve soil fertility, reduce erosion and increase the resilience of ecosystems. Thus, integrating olive groves into global carbon sequestration strategies can bring significant environmental benefits while maintaining sustainable agricultural yields.

/// Solution for a Resilient Future ///

Agroforestry, as an agricultural practice that deliberately integrates trees into croppinaThe use of cover crops in olive groves, whether legumes, non-legumes or a mixture, has become more widespread in recent years as an environmental sustainability practice aimed at improving organic matter soil as well as better environmental management in the face of climate change, particularly carbon sequestration. In this respect, in northern Tunisia, the main components of the agroforestry system in olive groves are represented as follows:

- Olive trees + multi-species market gardening: irrigated without being in water-saving mode. These are the plots with sprinkler or “seguias” irrigation methods. These are plots combining olive trees and associated vegetable type market gardening (a mixture of species of market gardening). These plots have an average diversity, that is to say they have between 2 to 3 types of association, one type of which is exclusively species of hedges or spontaneous vegetation. One fifth of these systems are located in hilly environments (high slope). It is true that market gardening is the most dominant type of association in this class, but there are a third of systems which also contain fruit trees of other types (fig or pomegranate trees).
- Olive trees + fodder: The plots are often irrigated by sprinkling.
- Olive trees + fruit trees (almond tree): The majority of these systems are rainfed. The pipe is rainfed. The diversity is average, that is to say they have between 2 to 3 types of association, one type of which is exclusively species of hedges or spontaneous vegetation.
- Olive trees + cereals: characterized by plots cultivated with cereals. They are rainfed. Diversity is low. There are no hedges or spontaneous vegetation. One fourth of the plots are in hilly environments.

The advantages of agroforestry based on olive trees firstly provide a supply service. As for regulating services, olive trees guarantee a permanent cover to the ground protecting it from wind and water erosion. This creates, on the one hand, a microclimate favorable to the development of biological activity in the soil. On the other hand, thanks to their aerial and underground woody biomass and their litter, trees increase carbon storage and therefore climate regulation. In terms of supporting services, olive-based agroforestry contributes to nutrient recycling. In fact, tree roots explore the soil deeper and thus recover leached mineral elements. It also promotes natural

processes (biological nitrogen fixation, soil reconstitution and natural enemies of pests), water regulation (water purification, erosion regulation).On the agronomic level, the presence of olive trees in agricultural plots makes it possible to strengthen the microbial life of the soil thanks in particular to the fall of the leaves which constitutes a contribution of organic matter (therefore contributing to the storage of carbon), constitute a moderating element with regard to climatic hazards.g systems, plays a crucial role in carbon sequestration, which contributes to climate change resilience in several ways:

- Atmospheric carbon fixation: Trees absorb atmospheric carbon dioxide (CO2) during photosynthesis, converting this carbon into organic matter and incorporating it into their cellular structures. This process, called carbon fixation, helps reduce the concentration of CO2 in the atmosphere, a greenhouse gas responsible for global warming.
- Long-term storage: Trees act as carbon sinks, storing carbon captured during their growth in wood, roots and soil. Agroforestry systems, by incorporating trees into agricultural areas, create long-term carbon reservoirs.
- mproved soil structure: Tree roots release organic compounds into the soil, promoting the formation of humus. This improves the structure of the soil, promoting its ability to store more carbon and retain water, contributing to resilience in the face of climatic variations, including periods of drought.
- Protection against erosion: Agroforestry systems help prevent soil erosion, which can be exacerbated by extreme weather events. By maintaining soil structure and reducing runoff, trees help maintain soil integrity and minimize carbon loss from erosion.
- Adaptability to changing conditions: Trees in agroforestry systems can be selected based on their resistance to changing climatic conditions, which strengthens the overall resilience of the agricultural system. Adapted tree species can better cope with temperature variations, extreme weather events and other impacts of climate change.

In sum, carbon sequestration in agroforestry offers a sustainable solution to mitigate greenhouse gas emissions, while providing resilience to agricultural systems in the face of the challenges posed by climate change. This underlines the importance of promoting this practice in the context of sustainable agriculture and the fight against global warming.



Agroforestry and climatic resilience: Wheat cultivation in olive trees in an agricultural field in Utique, northeast Tunisia
Author: Samir Ghannem | © Samir Ghannem



Agroforestry: A carbon sink for climatic challenges
Author: CIRAD | © CIRAD

/// Always Moving Forward ///

Agroforestry is a method of establishing rows of trees in the heart of agricultural plots. The challenge is to play on the possible interactions between cultivated plants and selected rare species, but also with animals raised to optimize and diversify its production. As for the disadvantages of agroforestry systems based olive trees, they are quite few in number but are essentially due to two factors: the potential competition of the chosen species with each other and with crops, particularly for water resources, nutrients or sunlight.

However, the reasons for practicing agroforestry are also multiple and reflect the challenges that farmers face, particularly in terms of managing production factors. In this context, the evaluation of the environmental, social and economic sustainability of existing olive agroforestry systems, as well as the development of more efficient systems should be part of the orientations of Tunisia's agricultural policies in terms of sustainable rural development.

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Innovative approaches for crop rotation and integration of legumes on a farm in Ghardimaou, North-West Tunisia

On a farm in Ghardimaou, in the northwest of Tunisia, the increase of agricultural resilience is being promoted through the judicious integration of vegetables into crop rotations.



A farmer waters pumpkins, peppers, corn and tomatoes on his farm in Ghardimaou. Combination crops with the intentional planting of trees and shrubs.
Author: Sondes Fkiri | © Sondes Fkiri



On a farm in Utique, North-East Tunisia, crop rotation (pepper, tomato, potato) offers farmers a diversification of their sources of income.
Author: Samir Ghannem | © Samir Ghannem

/// Context ///

Crop diversification promotes the resilience of agricultural systems by minimizing risks from specific diseases and optimizing land use. Additionally, adopting soil conservation techniques, such as agroforestry, minimum tillage, and permanent plant cover, helps prevent erosion and improve overall soil health. These initiatives have generated significant results on a farm in Ghardimaou, North-West Tunisia.

Crop diversification has strengthened the resilience of agricultural systems to climatic hazards and specific diseases, thus ensuring increased food security. Soil conservation techniques have improved soil structure and fertility, increasing agricultural productivity while preserving natural resources for future generations.

The main expected results are:

- Increased water management efficiency, leading to reduced pressure on water resources through more targeted and economical use.
- Increased crop diversification and biodiversity, leading to improved resilience of agricultural systems to climatic hazards, pests and diseases.
- Improving soil physical and biological properties by improving soil structure and fertility, thereby increasing agricultural productivity.

The main added value for practitioners lies in creating more sustainable, resilient and productive agricultural systems, thereby contributing to increased food security and the long-term preservation of natural resources.

/// Solution for a Resilient Future ///

Crop rotation and the integration of legumes into crop rotations is a practice that consists of not using the same land for the same crops in two consecutive years. This practice helps to prevent soil erosion, improve soil quality and biodiversity, limits the risk of disease transmission and reduces parasite populations Several farmers in the north-west region of Tunisia continue to use this practice, which allows them to minimise the use of chemical fertilisers and pesticides, which are harmful to the environment and biodiversity, particularly pollinators.

Farmers generally do not follow a specific crop rotation plan. They choose to rotate crops according to their individual needs, possibilities, market demand, environmental conditions and budget. Farmers take several factors into account when selecting crops to rotate. They assess profitability, the nutritional requirements of previous crops and local market demand. They also consider each crop's ability to enrich the soil with specific nutrients, control weeds and improve soil structure. For example, legumes are often included because of their ability to fix nitrogen in the soil, which is beneficial for subsequent crops.

However, farmers determine the timing of crop rotations based on the growth cycles of different crops and climatic conditions. They may alternate between seasonal and annual crops to maximise the use of natural resources. Rotation can be planned to make the most of periods of rain

and sunshine, or to avoid peaks in certain diseases or pests. During the rotation, farmers use different strategies to fertilise the soil. Legumes contribute to natural fertility by fixing atmospheric nitrogen in the soil. In addition, farmers may choose to use organic fertilisers such as compost or manure to improve soil structure and health. Some may also use green manures, which are specific crops planted to be incorporated into the soil to enrich its nutrient composition. This approach allows farmers to adapt their practices to local conditions and available resources, promoting efficient and sustainable crop rotation.

Crop rotation increases soil nutrients and prevents the accumulation of chemicals or toxic substances produced by certain crops. This allows farmers to grow crops successfully without the need for fertiliser. Diversified crop rotations help to increase yields, improve soil health and reduce greenhouse gas emissions. Crop rotations can reduce the risks associated with climate change and should be considered an essential element in meeting the challenges of global food production. Systems approaches to environmental sustainability and crop resilience, such as diversified crop rotations, are at the heart of risk reduction strategies and will be useful in guiding future agricultural decisions.



An example of a rotation involving three crops (Onions, beans, parsley) on a farm in Ghardimaou, northwest Tunisia. | Author: Samir Ghannem | © Samir Ghannem



In a crop rotation system, a farmer never grows the same plant for two successive seasons. Author: Sondes Fkiri | © Sondes Fkiri

/// Always Moving Forward ///

Farmers may encounter several difficulties when trying to implement crop rotation and legume integration:

- Limited knowledge and training: Some farmers may lack information or in-depth training on crop rotation practices and the benefits of integrating legumes.
- Limited resources: Setting up an effective rotation may require additional resources such as specific equipment, suitable seeds or crop management knowledge. Farmers with limited resources may find it difficult to adopt these practices.
- Fluctuating market and demand: Fluctuating market and local demands can make it difficult to select which crops to incorporate into the rotation. Farmers may be reluctant to plan their crops based on potential demand if the latter is unstable.
- Transmission of traditional knowledge: In some regions, traditional knowledge on crop rotations may be lost or disappearing, making it difficult to preserve and put into practice these ancestral practices. These difficulties can hinder the effective implementation of crop rotation and legume integration, requiring appropriate support, training and resources to overcome these obstacles.
- Traditional knowledge on crop rotations may be lost or disappearing, making it difficult to preserve and put into practice these ancestral practices.

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Fodder crops selection as a tool for food security under climate change in Tunisia

Achieving food security under the challenges of climate change and agro-sustainability requires ensuring fodder autonomy.



Climate change can affect the production of plants in pastures and the vegetation patterns of large-scale rangelands, as well as livestock production.
Author: Sonia Mbarki | © Sonia Mbarki



Medicago sativa, from variety Gabes: a Fabacea plant selected from southern Tunisa tolerant to drought.
Author: Sonia Mbarki | © Sonia Mbarki

/// Context ///

Climate change is a threat to livestock production because of the impact on the primary productivity of forage crops and rangelands, the reduction of quality of feed crops and forages, reduction of water availability and biodiversity, increase of livestock diseases, among others. As a developing country, Tunisia is highly vulnerable to climate change due to the predominance of agriculture in its economy and its warmer baseline climate, as well as its limited resources to adapt to new technologies.

Climate change and rising temperatures may increase evapotranspiration, including the evaporation of water from soils. As a result, water evaporates and the salt remains in the soil, increasing the soil salinity and consequently affecting the primary productivity of forage crops and rangelands. Optimizing forage availability using local spontaneous plants tolerant to environmental constraints can help minimize the adverse effects of climate change and ensure livestock productivity. Food legumes are crops that can improve soil fertility and crop rotation. They are a valuable source of protein for both human and animal nutrition. The development of new cultivar of the species, that present higher tolerance to these conditions was carried out and tested. The new alfalfa cultivar, designated as Gabes, increased significantly the salinity tolerance.

/// Solution for a Resilient Future ///

It is recognized by the scientific community that in the coming decades, forage crops will continue to be exposed to warmer temperatures, elevated carbon dioxide levels, and highly variable water availability due to changing rainfall patterns. Meanwhile, climate change is a threat to livestock production because of the impact on quality of feed crop and forage, water availability, animal and milk production, livestock diseases, animal reproduction, and biodiversity. Climate variability will limit livestock production as animal water consumption is expected to triple and forage production will be severely affected.

Food legumes are crops that can improve soil fertility, and are beneficial under crop rotation management of agricultural land. These Fabaceae plants can act as biostimulants, improving nutrient use efficiency and promoting quality traits. Additionally, they are more resilient to abiotic stress and can enhance the availability of nutrients in the soil or rhizosphe. They are also a valuable source of protein for both human and animal nutrition. To address the challenges of climate change effects on food legumes, the selection of genotypes that are more tolerant to abiotic stress may play a crucial role. In Tunisia, Algeria and Morocco, the supply of forage units from natural rangelands is declining. In this context, Lucerne is a key crop in many arid and semi-arid regions, where soil and water salinisation affects and limits plant growth.

The development of new cultivar of the species, that present higher tolerance to these conditions was carried

out and tested. The new alfalfa cultivar designated as Gabes, increased the salinity tolerance in the presence of salinity (between 50 – 150 mM NaCl). When compared in terms of germination rates, no difference was found between the two seed groups under normal conditions and salt stress. However, under saline conditions, the pre-treated seeds had a significantly higher germination rate (80%) compared to 90% for the control seeds. This variety of lucerne from Gabes, with a high protein content, can also be used under irrigation with saline groundwater such as the valley Mejerda (3 – 6 g NaCl/l). The widespread use of this species is beneficial to localc farmers due to its high adaptability, fodder yield potential and good quality of the final product.

The deep root system of lucerne can help to conserve soil and prevent water loss in arid areas. Medicago sativa is able to maintain good nutritional value under stress conditions. It is used in traditional agro-ecosystems (oases) where it accounts for over 80% of fodder crops and contributes to the socio-economic development of local families. The main centres of production are the oases on the east coast, particularly those of Gabes. It is also grown in the western continental oases of the Jerid region (Kebili and Tozeur). About 75% of the oasis area devoted to lucerne is located in southern Tunisia and its average area reaches 12,410 hectares (CRDA, 2007).



Medicago ciliaris in Tunisia, it grows spontaneously in northern areas; restricted to humid, sub-hum.
Author: Sonia Mbarki | © Sonia Mbarki



Vicia Narbonsis is fodder plant and human food without gluten.
Author: Sonia Mbarki | © Sonia Mbarki

/// Always Moving Forward ///

In challenging situations such as land degradation and water scarcity, it is necessary to enhance the resilience of fallow forage legumes that are highly vulnerable to climate change. Farms are shifting away from pastoral sheep, which require large natural pastures, and are increasingly focusing on bovine production using rainfed and irrigated fodder. Grain legumes are a major source of dietary protein with a multifaceted impact on the ecosystem. Grain legumes can allocate photosynthates to roots and nodules, improving plant biomass, rhizospheric activity, and input use efficiency. In rainfed conditions, forage legumes and cereal-forage legume associations can play a prominent role. Forage legumes such as *Medicago sativa, Medicago ciliaris, Vicia narbonsis, Vicia dativa*, and *Hedysarium coronarm* could be used as a sustainable fodder base. These legumes can be integrated into cereal rotations and grown on overgrazed soil. When combined with one or more annual grasses, they can provide abundant and high-quality hay. To test the efficiency of these forages, research centers (INRAT and INGC) developed their use with farmer pilot stations and seed producers. Demonstrating results and good practices in these stations is crucial for promoting farming and pastoral activities in Tunisia.

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Traditional agroforestry systems as hotspots of agrobiodiversity: The case of oases in Tunisia

Multilevel Agriculture improves environmental health, yield, and resilience under climate stress.



The three levels of the oasis system: palm trees, fruit trees, annual crops.
Author: Anselm Duchrow | © CCC/GIZ



Crop layering and structure of plots in Tozeur.
Author: Zied Haj-Amor | © Haj-Amor et al. 2018

/// Context ///

The oasis has a special microclimate that contrasts with the hostile desert environment and the harsh climatic conditions that make human life very difficult. These oases prevent the advance of desertification, play a role in the ecological balance, maintain biodiversity and are real oxygen lungs for the towns and villages close to them. The “oasis effect” allows the practice of various cultures, the list of which is long.

The crops are grown on 3 floors. The first floor is for date palms, the second for fruit trees, and the third for vegetables and fodder crops. In the oasis practically everything can grow, this characteristic makes it a place with the highest rate of intensification. Oases contain an extraordinary wealth of flora and fauna biodiversity.

There are more than 300 varieties of palm trees, some of which have staggered ripening, several varieties of olive trees, pomegranate trees, including the very famous Gabsi variety, which has obtained the “appellation d’origine contrôlée”. Several varieties of fig trees, several varieties of figs, grapevines, apricots and other tree species such as apples, pears, peaches, plums, mulberries, quinces, lemons, the famous pistachios of El Guetar, castor oil, some local varieties of bananas. As for fodder crops, we find alfalfa, of which we know the variety “alfalfa de Gabes”, and sorghum, as well as a long list of vegetable crops, some of which are local as Cereals, henna, tobacco, koreta, spices, mint and the rosebus.

/// Solution for a Resilient Future ///

Deserts are among the most hostile environments, with high temperatures and water scarcity. However, since ancient times, humans have developed techniques for harvesting and storing rainwater and groundwater resources. These techniques have allowed them to create oases, areas where they can establish settlements and carry out agricultural activities.

The main crop in Tunisia’s oases is the date palm (Phoenix Dactylifera), which was one of the first five fruit trees to be domesticated, along with the olive, grape, fig and pomegranate, as part of the “first wave” of domesticated fruit trees. As sustainable agro-ecosystems, oases are therefore linked to traditional agricultural practices and the livelihoods of local communities. In fact, in traditional oases we find not only date palms, but also other crops, with a wide variety of fruit tree species, herbaceous plants and also honey production, making these agricultural systems particularly rich in agrobiodiversity and a fundamental livelihood resource for local communities. In addition, diversified traditional agricultural practices are receiving increasing attention for their role in creating important microhabitats for wildlife and spontaneous plant species.

The agricultural system characteristics of Tunisia’s mountain oases (Midès, Chebika, Tamaghza) is traditionally organized into three vegetation layers: the top layer is generally made up of date palms, the second layer is made up of smaller fruit trees (figs, almonds, olives, pomegranates), and the third and lowest layer is made up of annual crops such as cereals (barley, wheat, sorghum), lucerne (the main fodder crop), and various vegetables. the third stratum is particularly important for

the livelihood of local communities, providing a variety of vegetables for family consumption and fodder for animals. Twenty one vegetable species and two forage crops are grown at the Midès, Tamaghza and Chebika oases. In addition, native seed varieties continue to be stored and planted, thanks to home seed saving, firmly supporting the unique food culture that is also considered a regional attraction. Local crops found in the oases are mainly peppers (Midès), pumpkins (Midès), onions, chard, lettuce (Chebika), parsley, jute mallow (Chebika), okra (Chebika). Midès appears to be the oasis with the highest vegetable recovery rate (13.8%), and in fact is known for the production of a specific variety of chilli pepper, grown by many farmers.

Thanks to this composite structure, each crop creates favourable conditions for the others in terms of solar radiation, humidity, shade and microclimate. Date palms, fruit trees and annual crops intercept about 20%, 20% and 40% of the daily net radiation, respectively. Tunisian mountain oases are considered traditional oases with a high level of integrity in terms of agrobiodiversity, land use system and social aspects. However, like many other traditional oases in North Africa, they have faced major changes in recent years, mainly due to the ageing of the local population, the migration of young people to the cities, the high production costs compared to the market value of dates, and water scarcity.



Crop layout and structure of plots in Gabes.
Author: Carpentier | © Carpentier, 2012



Environmental functions of the Oasien agro-system offers sustainable solutions.
Author: Basma | © IRMC

/// Always Moving Forward ///

Traditional oases continue to play a vital role in the maintenance and enrichment of genetic resources and agrobiodiversity. The genetic diversity of date palms and other crops in oases is essential to cope with climate change, economic and other pressures. It is important to preserve existing varieties, avoiding monocultures and preserving traditional oasis knowledge. In addition to their contribution to agricultural production, oases play an important role in preserving biodiversity, cultural and landscape heritage, as well as activities such as livestock breeding and beekeeping that support the local economy.

International programs, such as the FAO's GIAHS program, can play a key role in conserving traditional farming systems and agrobiodiversity. It is important that these programs take into account traditional characteristics while improving farmers' quality of life through innovation and access to better markets for local products. Improvements to farmers' quality of life thanks to innovations that respect the traditional features, such as a more efficient irrigation system or better market opportunities for local products, help to maintain these systems that can also represent examples of resilience and adaptability towards new global challenges, such as climate change.

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Enhancing Rainfed Production of Smallholder Agriculture by Managing Water Harvesting in Tunisia

Strengthening the management of water resources to promote sustainable rainfed agriculture.



Individual cuvettes are a traditional technique for collecting runoff water in arid and semi-arid regions dominated by dryland farming.
Author: GDA Sidi Amor | © CC-BY-4.0



Tunisian farmers use an ancestral technique ("Jars") to irrigate their olive trees basins where olive trees grow.
Author: DW | © CC-BY-4.0

/// Context ///

More than 75% of the world's arable land is used for rain-fed agriculture. In Tunisia, agriculture is primarily rain-fed, with only 8% of the cultivated area, approximately 420,000 hectares, benefiting from irrigation. One of the main challenges facing Tunisia is the efficient use of water resources for rainfed agriculture, a challenge that is expected to increase in the near future due to climate change, particularly changes in the rainfall regime. Throughout the country, rainfed agriculture faces challenging climatic conditions, as arid and semi-arid climates prevail over more than three-quarters of the total land area, with less than 300 mm of rainfall per year.

Water harvesting represents an untapped potential for the predominantly rainfed agricultural systems. The main challenge for rainfed agriculture is to mitigate the risks associated with significant variability in resource availability, particularly prolonged drought. Rain-fed agriculture is a key approach for the future of agriculture in Tunisia under water scarcity, given the technical requirements, associated costs and social issues associated with the use of non-conventional water resources such as desalination and reuse of treated wastewater.

/// Solution for a Resilient Future ///

Water harvesting presents untapped opportunities for the predominantly rainfed agricultural systems in arid regions of the developing world. Water harvesting stands as a promising alternative to combat desertification in arid and semi-arid regions, particularly in addressing the challenges posed by water scarcity. The collection of water using berms and dikes is an essential agricultural practice for controlling water runoff, reducing soil erosion, and preserving nutrients within the agricultural system, thereby contributing to a more sustainable and environmentally friendly agriculture.

The central challenge in rain-fed agriculture revolves around mitigating the risks associated with the substantial fluctuations in resource availability, with a particular focus on addressing the adverse effects of drought during crucial stages of plant growth, rather than just managing a severe water scarcity situation.

The "jars" technique represents a rich cultural heritage passed down through generations of Tunisian farmers. This traditional method involves the use of large clay jars buried in the ground to collect and store rainwater. Farmers have developed intricate systems for positioning and maintaining these jars to maximise water collection and retention, particularly in arid regions where water scarcity is a major challenge. Over the years, farmers have refined their skills and knowledge in the construction, placement and management of these jars, adapting them to local environmental conditions and

agricultural practices. As well as providing a practical solution to water management, the jar technique reflects the deep attachment of Tunisian farmers to their land and their resilience in the face of environmental challenges.

The Jars is a technique that provides controlled irrigation to crops using buried, porous, unglazed clay pots. The rate at which water seeps through the walls of the submerged clay pot depends on the plant's water consumption. When the soil dries out, the pot acts as a reservoir, supplying the roots with just the right amount of water. This technique is exceptionally effective, surpassing even conventional surface irrigation and drip irrigation, with efficiencies up to ten times greater. What is more, this ancient method achieves its aim while conserving water, using around 60 per cent less than traditional methods. The 'jar' technique has also proved particularly effective in saline soils or where saline irrigation water is required. It has been shown to be useful in land restoration efforts in extremely arid environments, making it a valuable tool for agricultural practices in challenging conditions.

The use of water harvesting techniques promotes:

- Effective control and management of run-off water, soil protection and conservation;
- The increase productivity of marginal land and the maintaining of traditional agriculture;
- The development of rainfed agriculture and the maintenance of a productive agricultural heritage;
- Groundwater recharge and the protection of downstream areas from sediment deposition (siltation).



Dry stone cordons for controlling runoff, preventing excessive soil erosion, and allowing water infiltration into the soil. | Author: Sihem Jebari | © Educational use, non-commercial..



Jessour is one of the most important traditional hydroagricultural techniques for harvesting rainwater in southern Tunisia. | Author: CTV Mareth | © Educational use, non-commercial.

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Some of the large-scale water and soil conservation projects mentioned above require preliminary studies that take into account the pedology, hydrology and geomorphology of the site. Water and soil conservation developments aimed at improving agricultural production and increasing yields must be accompanied by improved agricultural practices. Training, awareness-raising and agronomic advice must therefore be provided systematically in parallel with the construction of physical structures, with the involvement of the Agricultural Advisory and Training Agency (AVFA), the General Directorate for Agricultural Production (DGPA) and researchers (for the implementation of the techniques they recommend in the field). It is also essential to involve and motivate farmers, as they are the ones who will have to implement the farming techniques.

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Type of solution: Management Sector: Agroforestry, Forestry

Good practice(s): Water management, Soil management, Management alternatives, Community engagement

Afforestation of degraded land in the arid zone of Tunisia using the Moringa tree

Nutritional value and growth characterisation of a fast growing species with multiple uses for arid and semi-arid ecosystems.



Water restriction, degradation of arable land, extension of aridity over most of Tunisian territory.
Author: Ahmed Boumenjel | © Educational use, non-commercial.



Support for the actors of the sector (rural women and small farmers), and support for the establishment (transplantation) of young Moringa plants from the nurse.
Author: Boumenjel Ahmed | © Educational use, non-commercial.

/// Context ///

Different strategies can be adopted to combat climate change and rising atmospheric temperatures, which intensify water restriction and promote the expansion of arid and semi-arid zones across most of Tunisian territory. This leads to the degradation of cultivated land and limits the reproduction and survival of native plants and their agricultural production. The introduction of plant species with high nutritional, grazing and fodder value, and of practical importance for the restoration and valorisation of degraded soils, represents an emerging ecologically effective approach.

It is in this context that we chose *Moringa oleifera* (L), a fast-growing and multi-use species (nutritional, fodder, socio-economic, industrial, etc.). Because it is cultivated and naturalized in all arid and semi-arid ecosystems, *Moringa oleifera* emerges as a distinctive contributor, showcasing its versatility in bioenergy applications. The seed oil emerges as a promising resource for energy production, offering a sustainable alternative to conventional fossil fuels and addressing climate change challenges.

Moringa oleifera can be cultivated in agroforestry, a sustainable land management system that integrates agriculture and forestry principles, promoting diversity, productivity, and resilience. This practice offers ecological, economic, and social benefits, such as enhanced biodiversity, improved soil fertility, water conservation, and additional income sources for farmers.

/// Solution for a Resilient Future ///

Moringa is a very resistant tree native to India, which has become cultivated in many tropical countries in Asia and Africa. It is part of the diet of local populations where it is native, with the seeds and leaves being the most commonly consumed parts. These can be used fresh, dried or cooked. In Europe and worldwide its leaves are renowned for their multiple virtues, most frequently being dried and then reduced to powder.

The composition of Moringa is particularly rich from a nutritional point of view. For example, 100 g of fresh pods or seeds contain: 3.41 g protein, 8.5 g carbohydrates, 6.05 g fat, 4.8 g fiber, 4.84 g cellulose, 0.004 mg vitamin A, 141 mg vitamin C, 751.6 mg vitamin E, 30 mg calcium, 110 mg phosphorus, 50.84 mg potassium, 1.8 mg iodine, 5.3 mg iron. This exceptional wealth of nutrients is reflected in the added nutritional value of these Moringa products for the human body, making it useful to fight fatigue, for preventing infectious diseases, anemia and mineral and vitamin deficiencies. Moringa is also a powerful source of antioxidants, containing polyphenols and flavonoids. In addition, novel isolates such as muramoside and niazimin have been identified in the plant and have anticancer, antihypertensive, hepatoprotective, and nutritional effects.

Dry pod berries/seeds of the *Moringa oleifera* (L) can be ground to be used as a feed supplement for farmed poultry. In our case study, the addition of 15-20% of one of these products to a feed ration considerably improves the protein, essential amino acid, vitamin and mineral content, thus contributing to improved animal health and growth.

Moringa is starting to make a big splash in Tunisia, where was recently introduced and its cultivation appears to be successful. Generally, it is the *Moringa oleifera*, among all existing species, which is cultivated and consumed. It is a fast-growing tree, taking just 3 to 6 months to harvest its first leaves and a year and a half for the first fruit harvest.

In the Tunisian regions of Manouba (semi-arid with mild winter) and Sidi Bouzid (arid with cool winter), a study was implemented where the Moringa is cultivated both in a monoculture plantation and in an agroforestry system consisting of alleys were it is associated with peas (Pisum sativum). Analysis of the results from the 12-month growth and development field experiment showed that climatic conditions in Manouba and Sidi Bouzid regions significantly favored trunk growth. This was confirmed by a relative growth rate of about

0.44 cm/month, a 45.34% increase in the number of branches and an increase in the phytovolume of the shrubs, estimated at 23.67 g/cm3. The *Moringa oleifera* stem and crown development also shows a high ability to capture and store nutrients and water in the roots, enhancing its potential in arid and semi-arid climates.

INRGREF works with many farmers to build their capacity for the commercial cultivation of *Moringa* trees. We propose the usage of the *Moringa oleifera* (L) as one of the solutions to rehabilitate, restore and improve soils and ecosystems, as an alternative adapted crop to climate change, and suitable for regions with reduced water resources and degraded soils.



Artisanal irrigation (by canister), adopted by a rural woman / Application of good practices and techniques for the maintenance of young plants of M. oleifera.
Author: Boumenjel | © Educational use, non-commercial.



Successful planting / good acclimatization of M. oleifera, in the arid and semi-arid Tunisian zones.
Author: Ahmed Boumenjel | © Educational use, non-commercial.

/// Always Moving Forward ///

Despite these encouraging results, certain challenges have been encountered in cultivating the species. These include:

- Need to keep the crop away from or protect it from herbivores, particularly goats, due to the high palatability of young moringa shoots.
- Need to protect the plants during cold nights, since young moringa plants are sensitive and 30% of the leaves can fall off during this period, delaying flowering and consequently fruit production.
- Growth of young shoots in heavy or clayey, drained soils.
- The need for pest and disease control, which, although rare, can be problematic and require special attention to avoid yield losses.

We recommend guidelines for future action:

- Promote the use of Moringa trees in Tunisia, enhancing local biodiversity and carbon sequestration.
- The use of Moringa trees in Tunisia to restore degraded land. These restored areas can absorb carbon dioxide 20 times more effectively than the general vegetation.
- Training farmers to grow Moringa trees. Such activities are currently taking place in the north and south of Tunisia, with 50% of participants being women.
- Stimulating economic development through INRGREF's activities, which are estimated to have enabled "moringa ventures" and green village businesses.

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Jessour of southern Tunisia: Agriculture in marginal areas and protection against erosion

Jessour is an ancient runoff harvesting technique practiced in the arid highlands of southern Tunisia.



Jessour is the hydraulic unit made of the dyke, the spillway, the terrace (cropping area: fruit trees and annuals), and the impluvium (runoff catchment area)
Author: El Athmane, Beni Khedache | © WOCAT



Conservation of water and soil using the "Jessour" technique in the arid highlands of southern Tunisia. Beni Khedache, Medenine
Author: Ouessar M. (Medenine, TUNISIA) | © WOCAT

/// Context ///

Faced with increasing challenges of water management and soil conservation in agricultural areas, farmers face problems such as soil erosion, loss of fertility and resource dependence limited water. Climate change is increasing pressure on these resources, making it imperative to adopt sustainable practices. However, in the arid highlands of southern Tunisia, particularly in Beni Khedache in Medenine, Gabès, Matmata and Tataouine, the Jessours stand out as an ingenious and sustainable solution to meet these challenges. These land developments, rooted in tradition, are designed to maximize the use of rainwater, prevent erosion and promote efficient management of agricultural land. They represent a natural and respectful way to create systems resilient to climate change. The Jessours are strategically constructed to capture and retain rainwater, allowing for more efficient use of precious water resources. These structures act as natural ramparts, slowing water runoff and preventing soil erosion, thus preserving the fertility of the land. In the face of climatic variations, Jessours offer valuable adaptability by allowing farmers to better manage the impact of unpredictable weather conditions. By promoting sustainable water use and preserving soil health, Jessours contributes to the creation of a sustainable and resilient agricultural environment. Adopting the Jessours technique represents a tangible opportunity for farmers to transform challenges into sustainable opportunities

/// Solution for a Resilient Future ///

Arid and semi-arid regions face major water management challenges, with erratic rainfall and risks of soil erosion posing significant threats to traditional agricultural practices and local food security. In response to these pressing issues, Jessours emerge as practical and ingenious solutions in these environments. Jessour technology is typically practiced in mountainous dry regions with low annual precipitation and medium to high slopes. Constructing contoured terraces and utilizing local materials, Jessours maximize water retention and minimize erosion, offering a sustainable approach to address these challenges.

The Jessour (plural of jisr) are developed in the mountainous areas of Gabès, Medenine and Tataouine where the altitude varies between 400 and 600 m and an annual rainfall varying between 100 and 150 mm. In this area, there are around 35,000 jisr, each of which receives additional runoff water of around 300 to 500 mm annually. Originating from the installation of ancient olive orchards based on rainfed agriculture in rugged landscapes, Jessour not only ensured local self-sufficiency but also supplied neighboring areas with agricultural products like olive oil, dried figs, and palm dates.

By definition, the term “Jessour” refers to the hydraulic unit comprising three components: the impluvium, the terrace, and the dyke. The impluvium, or catchment area, collects and conveys runoff water, demarcated by a natural water divide line. Each unit has its own impluvium but can also receive excess water from upstream units. The terrace, where farming is practiced, forms gradually through sediment deposition, creating an artificial soil layer up to 5 meters deep near the dyke. The dyke, typically made of earth, serves as a barrier to retain sediment and runoff water, featuring central and/or lateral spillways and abutments for excess water evacuation. Stabilized with dry stone coverings in older units, dykes mitigate erosive effects, while spillways dissipate overflow kinetic energy through stone arrangements resembling stairs.

Traditionally, Jessours support the cultivation of fruit trees (e.g., olive, fig, almond, date palm), legumes (e.g., pea, chickpea, lentil, faba bean), barley, and wheat on terraces. Beyond agricultural production, Jessours fulfill additional roles such as aquifer recharge through runoff water infiltration, flood control to safeguard downstream infrastructure and towns, and wind erosion prevention by trapping sediment within the mountain ranges of Matmata in southeastern Tunisia, limiting the deposits of fine sediments in the plain where the winds are very active.



Jessour allows the increase in the retention of runoff water and carryover materials in the soil, as well as the reduction of water erosion.
Author: OSS | © OSS



The jessours technique allows adequate management of runoff water, protection from the effects of water erosion, conservation of native flora.
Author: Insaf Cherif | © WOCAT

/// Always Moving Forward ///

The implementation of jessours, although beneficial, can present several challenges for farmers including:

- Limited resources: Farmers, especially in economically disadvantaged regions, may face financial and material constraints in constructing Jessours. Limited access to resources such as stones or wood can also hinder implementation.
- Traditional knowledge: Although Jessours are often based on traditional agricultural practices, their correct implementation requires specific knowledge. Farmers who are unfamiliar with these techniques may be hesitant to adopt them for fear of not implementing them correctly.
- Changes in agricultural Practices: Adoption of Jessours may require modification of established agricultural methods. Some farmers may be reluctant to change their usual practices for fear of disrupting their farming calendar or compromising short-term productivity.
- Land constraints: Farmers may face land constraints, limiting their ability to set up Jessours on their plots. Landowners may also be reluctant to allow such developments on their land.
- Ongoing maintenance: Jessours require regular maintenance to ensure their long-term effectiveness. Some farmers may face time or labor constraints in maintaining these structures in good condition.

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The Tabias and Jessour in South-East Tunisia: Ancestral Hydro-Agricultural Systems in an Arid Environment

Traditional techniques, modern solutions: The Jessour and the Tabia as tools of water and soil conservation in Tunisia.



Tabia with additional floodwater capture in Medenine, southern Tunisia.
Author: Sahara and Sahel Observatory | © Sahara and Sahel Observatory



Rainfed agriculture with Jessour in the province of Medenine, Tunisia.
Author: Insaf Cherif | © WOCAT SLM DATABASE

/// Context ///

The traditional Jessour and Tabias systems are crucial for water and soil conservation in Tunisia. The Jesser technique involves building small stone dams along slopes to prevent gullying, retain sediment, create soil, and temporarily retain water. The cultivation zone is established by using the natural watershed as an impluvium to trap surface water and sediments from the slope. This is done upstream of an earth dike (tabia) that blocks the thalweg perpendicular to the direction of flow. The surface of accumulation and storage of sediments and water is called jesr. These works concentrate water, allowing for a multiplication of rainwater resources by more than three. To help concentrate flows towards the jesr, a low wall is sometimes added on the slope. It is important to adhere strictly to metrics and units. Similarly, a dry stone wall called sirra can reinforce the tabia downstream. Weirs are also installed in the tabias to avoid or limit destruction during periods of flooding. These weirs can be single or double, central or lateral, and made of stone, masonry, concrete, or other materials. In addition to improving agricultural production, traditional systems also contribute to recharging groundwater, controlling flooding, and protecting downstream infrastructure while limiting water erosion. The Jessour and Tabias are effective ancestral techniques for preserving water resources and conserving soil in Tunisia. The works produced in southern Tunisia are widespread in the jebels, and the most advanced models can be found there.
They occupy every valley, even the narrowest, marking it with a flow of vegetation. The dark green crowns of the olive trees and the pale foliage of the fig trees contrast with the yellowish appearance of the arid slopes that dominate them.

Water resources and soil fertility: the effectiveness of Jessour and Tabias in water and soil conservation.

The tabias are built in the foothill areas of the Jebels and the plains with a slight slope (not exceeding 3%), in the southern regions of Tunisia, characterized by relatively low annual rainfall.

Jessour are techniques consisting of building dams across the thalwegs of wadis and ravines, thus making it possible to retain alluvium usable for cultivation and to retain part of the runoff water.



Jessour system between Toujane and Matmata. The menfes on the right of the first jesr and the puddles linked to precipitation, upstream of the stone tabias.
Author: CC-BY-4.0 | © N. Blond

/// Solution for a Resilient Future ///

Jessour and Tabias are practical solutions for arid and semi-arid regions. They maximize water retention and reduce erosion through the construction of contoured terraces and the use of local materials.

Jessour technology is typically used in mountainous, arid regions with medium to high slopes. This technique was responsible for the establishment of ancient olive orchards based on rainfed agriculture in rugged landscapes. This allowed the local population to achieve self-sufficiency and provide neighboring areas with various agricultural products, such as olive oil, dried figs, and palm dates (Phoenix dactylifera). Jessour, the plural word for Jessr, is a hydraulic unit made of three components: the impluvium, the terrace and the dyke.

- The impluvium, also known as the catchment, is the area responsible for collecting and conveying runoff water. It is bordered by a natural water divide line, which demarcates the boundary of a natural area or catchment, ensuring that all the rain that falls on this area is concentrated and drained towards the same outlet. Each unit has its own impluvium, but can also receive excess water from upstream units.
- The terrace, also known as the cropping zone, is the area where farming takes place. It is formed by the gradual deposition of sediment, creating an artificial soil that can be up to 5 meters deep near the dyke. Typically, fruit trees such as olive, fig, almond, and date palm, as well as legumes like peas, lentils, and faba beans, are cultivated on these terraces.
- The dyke acts as a barrier to hold back sediment and runoff water. It is made of earth and equipped with a central and/or lateral spillway (masref and/or manfes) and one or two abutments (ktef) to ensure the evacuation of excess water. The dykes are trapezoidal and measure15-50 m in length, 1-4 m in width, and 2-5 m in height. In old units, the dyke is stabilized with a covering of dry stones to overcome the erosive effects of water wave action on the front and back of the dyke. The spillway is constructed using stones arranged in a stair-like formation to dissipate the kinetic energy of the overflow.

Towards sustainable agriculture in Tunisia: Jessour and Tabias as tools for preserving aquatic and terrestrial ecosystem.



Tabia earth dam in the plain. Olive trees are generally grown along the dam, where the harvested water infiltrates better.
Author: Sahara and Sahel Observatory | © Sahara and Sahel Observatory

The jessour technique allows adequate management of runoff water, protection from the effects of water erosion, conservation of native flora with the aim of improving productivity per hectare.



Tabia on the piedont zone. Fruit trees (olive trees, almond trees, figs, palm trees, etc.) and annuals (barely, etc.) can be cultivated. Saykha, North Medenine
Author: Ouessar M. | © WOCAT SLM DATABASE

This technology is currently found in the mountain ranges of Matmata in southeastern Tunisia, where local agricultural activities rely mainly on rainfed agriculture and livestock breeding. The tabia system, on the other hand, is a recent innovation developed by mountain inhabitants who migrated to the gently sloping plains. These structures, which include earthen dikes and spillways, are primarily used for arboriculture and annual crops.

Tabia are mainly used for arboriculture and annual crops. In addition to their ability to harvest water, tabias have a positive effect on soil erosion and aquifer recharge.

The Tabias differ from the Jessour in that they include lateral bunds and sometimes small flood diversion dikes. They are constructed either manually or with machinery, depending on their size, and are commonly used in areas where the slope is less than 3% and the soils are deep. The use of tabias became popular among the residents of the nearby plains and foothills, converting their pastures into arable land in the central and southeastern regions of the country.

Although the Jessour and Tabias techniques were originally developed for agricultural crop production, they now serve three additional roles:

- aquifer recharge, via runoff water infiltration into the terraces
- flood control and therefore the protection of infrastructure and towns built downstream
- wind erosion control, by preventing sediment from reaching the downstream plains, where wind speeds can be particularly high.

/// Always Moving Forward ///

Water management is an essential pillar in arid climates, even more so in times of increasing climate change. The construction and management projects of Jessour and Tabias are proving to be key initiatives in ensuring constant access to water in these arid regions.

To meet the challenges and optimize the benefits of Jessour and Tabias for sustainable agriculture, a holistic approach is needed. This should take into account both technical aspects and socio-economic dimensions. Although these traditional water management systems have proven their effectiveness over time, they face several obstacles such as environmental degradation, changes in rainfall patterns, and socio-economic pressures. Nevertheless, their implementation can provide multiple benefits in terms of sustainable agriculture and environmental conservation.

Overcoming challenges and harnessing Jessour and Tabias for resilient agriculture.

Implementing these projects can be challenging, particularly in terms of resource availability, the technical nature of the tasks required, and overall feasibility. To ensure the success and sustainability of these initiatives, the assistance of qualified engineers and technicians appears to be an essential element.

However, despite their undeniable importance, the expansion of Jessour and Tabias may be hampered by various constraints. Among these, we can



Structure in the form of jessour. Construction of earth dikes reinforced with stones in thalwegs: Water conservation practices
Author: Tunisian Ministry of Environment and Sustainable Development
©Tunisian Ministry of Environment and Sustainable Development

mention, the need for adequate financial resources to build and maintain the infrastructure. Difficulties in accessing essential equipment and materials. Regulatory and administrative barriers that can delay project approval processes and extreme climatic conditions that can affect the durability of installations.

Although Jessour and Tabias have been used successfully for centuries, the integration of scientific advances and innovative techniques can greatly improve their effectiveness and resilience. It is crucial to adopt technologies that enable water monitoring, soil conservation, crop management, and the promotion of adaptive agricultural practices

Fruit trees and annual crops are commonly grown using tabia. Besides their benefits for water harvesting, tabias reduce soil erosion and have a positive effect on groundwater recharge.

in the face of changing environmental conditions. In addition, addressing socio-economic factors such as land tenure, access to resources and market opportunities is essential to promote the widespread adoption of jasmine and tabia. Investments in infrastructure, business partnerships, and agricultural extension services can go a long way toward helping smallholder farmers and rural communities reap the full benefits of these water management systems.

Despite these challenges, the benefits of Jessour and Tabias for sustainable agriculture remain significant, contributing to water conservation, improved soil quality and increased agricultural yields.

Build an earth dike sometimes consolidated with stones in thalwegs and depressions. The structure is reinforced downstream by a dry stone wall with a variable height (2 to 5 m) depending on the flow.

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Modernizing buried Jar Irrigation: Integrating advanced technologies for sustainable agriculture

The efficiency of irrigation by Jars, an ancient technique preciously preserved for cultivating crops with precision and care.



Buried Jar techniques, Southern Tunisia.
Author: Edjean | © Educational use, non-commercial.



In times of drought, Tunisian olive growers use proven traditional techniques (Jar) to irrigate their olive groves.
Author: DW.com | © DW.com

/// Context ///

Buried jar techniques, also known as underground irrigation or infiltration irrigation, are ancestral practices that date back several millennia and continue to be used in many regions of southern Tunisia. This ingenious method is based on the principle of burying earthenware jars or jars partially filled with water near the plants to be irrigated. In-ground jars often have small holes drilled into their walls, allowing water to slowly drain into the soil, nourishing plant roots in an efficient and controlled manner.

Irrigation by in-ground jars has many advantages. First, it allows for efficient water use because water infiltrates directly where the roots need it, reducing evaporation losses and overwatering. Additionally, this method helps maintain soil moisture consistently, which is particularly beneficial in regions that are arid or prone to periods of drought.

Another significant benefit of in-ground jars is their ability to reduce weed growth. By limiting water supply to specific areas where crops are grown, this technique discourages the growth of competing weeds, reducing the need for manual weeding or the use of harmful chemicals.

Buried Jar techniques, also known as subsurface irrigation, involve burying terracotta jars or jars partially filled with water near the plants to be irrigated.

Jar irrigation is an ancient technique used to supply plants with water.

Additionally, in-ground jar irrigation provides precise, targeted crop irrigation, which promotes healthy, vigorous plant growth. By providing water directly to the roots, this method allows plants to absorb nutrients optimally, which can result in higher yields and better crop quality. In addition, by limiting surface watering, this technique helps minimize salt build-up on the soil surface, beneficial for salinity-sensitive crops. This method is effective in a variety of soil conditions, including sandy and clay soils, where other irrigation methods may not perform as well. Buried jars maintain a constant source of moisture even in times of drought, helping crops to survive and produce yields despite arid conditions.

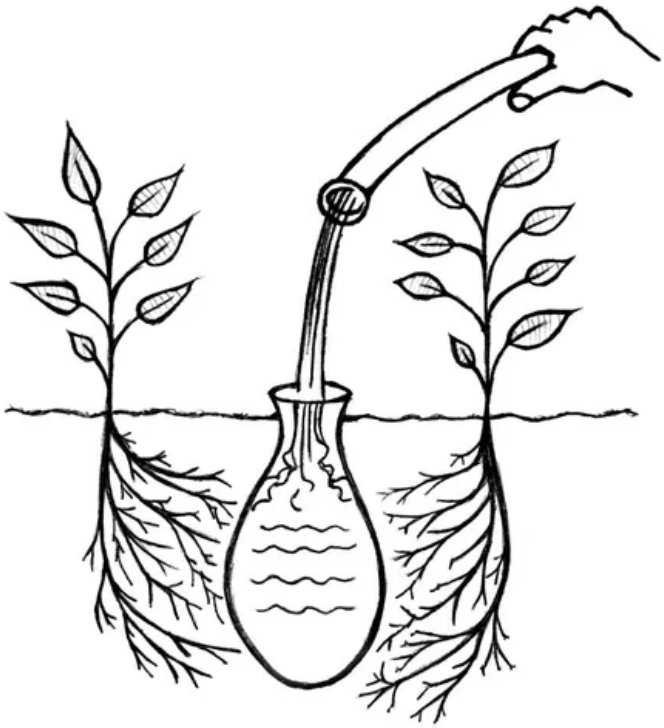
By using natural materials such as clay to make the jars, this technique is part of an environmentally friendly and sustainable approach to agriculture. In addition, by promoting more efficient use of water resources, buried jars contribute to the conservation of natural resources and the preservation of the local ecosystem.

Tunisian olive growers use proven traditional techniques to irrigate their olive groves. In times of drought, terracotta jars filled with water water the roots.

/// Solution for a Resilient Future ///

In Tunisia, a country where water is a precious and often limited resource, the use of the ancestral jar technique for irrigation represents an ingenious and sustainable solution to the challenges of agriculture in arid or semi-arid environments. The principle of irrigation jars is very simple. It is a terracotta container that is inserted into the ground. The wall of the jar is porous thanks to its material. The water gradually seeps outwards, depending on the needs of the plants, the particularities of the soil, the weather and the plants themselves (we sometimes speak of capillarity). The roots of the latter naturally tend towards the nearest water source. They roll up the jar and consume the quantity of water necessary for their growth.

Since the jar drains slowly according to the needs of the plants, its use will save 50 to 70% of water when compared to surface watering, which promotes evaporation. A real ally in a heatwave. In many regions of Tunisia, notably in Djerba, Sfax and Mednine, farmers have adopted this traditional practice to face challenges related to water availability. In-ground pots act as natural water reservoirs, providing a constant supply to plant roots while minimizing evaporative losses, which is especially important in a climate characterized by high temperatures and low humidity. However, the buried jar technique reduces water stress by providing a constant source of moisture to the roots, enabling plants to better tolerate periods of drought. Easy to install and implement, it is accessible to farmers with limited resources. By maintaining constant moisture, this method promotes an environment conducive to microbial life and beneficial soil organisms, improving overall soil health. What's more, it requires no external energy, reducing energy costs. The use of local materials to manufacture the jars supports the local economy and reduces dependence on imported resources. The technique is easily scalable, adapted to different scales, and helps prevent soil erosion by reducing surface runoff. It is also flexible, suitable for a wide variety of crops, enabling agricultural diversification. Finally, by ensuring adequate and constant irrigation, it helps to produce better quality



The porous walls slowly diffuse the water which will be absorbed by the plant roots.
Author: Stella | © Stella

crops, with more uniform and healthier fruit and vegetables. An exemplary case study on the use of jars for irrigation in Tunisia is found in the semi-arid region of Kairouan. Here, farmers have managed to maximize the use of available water by burying jars along rows of crops such as olive trees and vines. This method not only saved water but also improved crop yields and quality. Plant roots have access to a constant, regulated source of water, which promotes their growth and development, even in harsh environmental conditions.

In addition to its effectiveness in terms of water conservation, the use of jars offers other advantages. For example, this technique helps reduce the growth of weeds because water is delivered directly to the roots of cultivated plants, thus limiting competition for water resources.

Moreover, by using natural materials such as clay, the jars integrate harmoniously into the environment and contribute to an agricultural approach that respects the local ecosystem. However, despite its many advantages, the use of jars for irrigation

The Jars: an ancient heritage for resilient agriculture in Tunisia.

Plant roots naturally tend toward the nearest water source. They roll up the jar and consume the quantity of water necessary for their growth.



A farmer in southern Tunisia buries jars to irrigate his plants and fight drought.
Author: CAPTE | © CAPTE

Irrigation by jars has many advantages: it is simple and profitable, compared to conventional watering, it saves water (50 to 70%) by reducing evaporation and drainage.

requires careful management to optimize its effectiveness. Practices such as strategic pot placement, soil moisture control, and regular container maintenance are essential to ensure optimal long-term results.

In conclusion, the use of the jar technique for irrigation represents an innovative and sustainable solution to overcome the challenges linked to water scarcity in Tunisia. By combining tradition and innovation, this ancestral method offers an effective response to agricultural water needs while preserving natural resources and promoting sustainable food production in a context of climate change and pressure on water resources.

/// Always Moving Forward ///

The jar irrigation solution in Tunisia can be improved by developing training and education programs for farmers to help them better understand water management and irrigation optimization practices. Additionally, further research could be undertaken to assess the long-term impact of this method on crop yields, soil health and water conservation. Public awareness measures could also be considered to promote this traditional technique and encourage its adoption in other regions facing similar water availability challenges. However, the jar technique has disadvantages compared to other irrigation systems. Among others, we can mention:

- Fragility of the material: the jars break easily (accidental blows, or freezing).
- Arduousness of the installation: the jars must be buried.
- Low mobility: once installed for the season, the jar will be difficult to move (because the roots will already be established around the jars.
- Maintenance: the jars can end up clogging if you use hard water. Rainwater should therefore be preferred (NB: UV-protected water collector to limit the development of algae). You can also clean the interior once a year with slightly acidic water (water + white vinegar for example), and lightly sand the exterior part of the jars. This will extend their lifespan.

In addition, the jar technique is quite simple, but it is important to understand how it works and its main characteristics to ensure effective irrigation. Indeed, the main risk is that the jar is not permeable enough to provide the plant with all the water it needs. To do this, it is important to know in advance the irrigation needs of your crop, and to know how to choose or make the jars so that they can meet this need.

The main factors affecting the jar flow rate are:

- For the pottery itself: the materials used, the firing temperature of the pottery and the thickness of the wall.
- For the use of pottery: the quantity of water present in the olla; the humidity level of the earth surrounding the jar; the roots of the plants attached to the jar (which will absorb a variable quantity of water depending on the evapotranspiration of the plant).

We recommend in all cases, in order not to take any risks, to always choose a jar that is too permeable rather than not enough (which also increases the range of action of the jars), and to combine significant mulching of the soil to limit evaporation.

Optimization and expansion of Jar Irrigation in Tunisia: Improvements and innovations for sustainable agriculture.



A farmer burying a jar near a young olive plant in Sidi Bouzid, South Tunisia.
Author: Edjean | © Edjean

To ensure the continued success of this solution, it is essential to address potential challenges such as inadequate jar management, variations in water availability and changing crop needs. Additional investments in research and development could lead to

Public-private partnerships could be considered to expand this practice on a larger scale and increase its positive impact on food security and environmental sustainability.

To ensure the continued success of this solution, it is essential to address potential challenges such as inadequate jar management, variations in water availability and changing crop needs.

technological improvements, such as more durable jar materials or innovative irrigation systems.

New projects could explore modern applications of the buried jar technique, such as its integration with remote sensing technologies or smart irrigation systems for more efficient management of water resources. Using sensors and IoT (Internet of Things) networks, it would be possible to monitor crop water requirements in real time and adjust irrigation precisely, thus optimizing water use and reducing wastage. In addition, public-private partnerships could be envisaged to extend this practice on a larger scale. Such collaborations could include funding initiatives, training programs for farmers and the development of new infrastructure, thereby increasing its positive impact on food security and environmental sustainability. By combining traditional knowledge with technological innovations, this age-old method could be revitalized and adapted to the contemporary challenges of sustainable agriculture.



The Jars provide plants with constant humidity while saving water.
Author: Edjean | © Edjean

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Zai technique for dryland rehabilitation

Using a simple and low-cost method to restore degraded lands in the Mediterranean.



Field preparation – Farmers digging zai pits
Author: Dougbedji Fatondji | © Dougbedji Fatondji



Zai pit filled with organic matter
Author: Dougbedji Fatondji | © Dougbedji Fatondji

/// Context ///

The term zai refers to a simple yet effective technique where farmers dig pits in highly degraded and crusted drylands to capture water and nutrients and progressively restore the land for forestry or agriculture. This technique originates in the Sahel. Zai combines efficient water and nutrient management practices into a technique that can be used to restore degraded land, needs little external inputs, bears very low costs and requires no extra knowledge or technology, making it easily accessible to and manageable by small and poor farmers. But it can also be used in a more mechanized approach in larger farms (e.g. with machine borers). With climate change, aridification is expected to expand in the Mediterranean Basin, particularly in North Africa, Portugal, Spain and Greece. Hence, traditional rainwater harvesting and soil water conservation techniques like zai would deserve careful studies to anticipate their adaptation and use in the Mediterranean context. Soil fauna and biological processes would also need further studies to understand how they can fulfill the role that termites have in the Sahel.

/// Solution for a Resilient Future ///

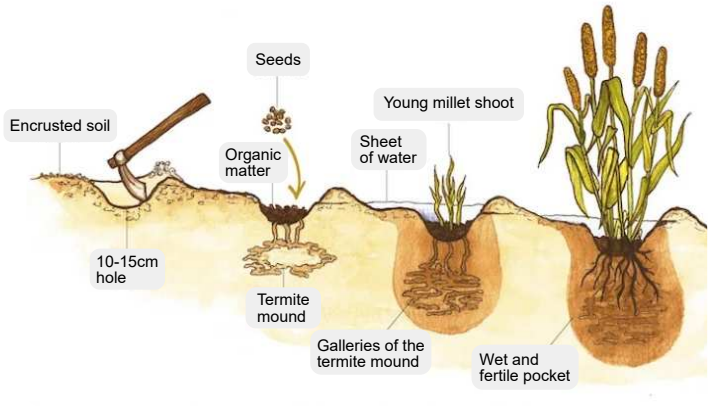
Agriculture in the Northern Sahel is faced with extreme soil and climatic conditions. The region experiences very low (< 400 mm/year) and erratic rainfalls, with frequent and intense dry spells. Rapid population growth and unsustainable practices (e.g. slash and burn, overgrazing and trampling) have accelerated land degradation and forced farmers to cultivate also the least fertile lands. Prevalent soil crusting limits water infiltration, accelerates run-off and aggravates soil erosion and degradation in a vicious circle.

After the severe droughts in the 1970s and 1980s, zai (or water pocket or tassa), a traditional rainwater harvesting, soil water conservation and soil restoration practice, was rediscovered and has been progressively disseminated among Sahelian farmers. Zai consists in digging holes, 20-40 cm wide, 10-25 cm deep to collect runoff water and wind-driven organic debris; adding organic matter (crop residues or manure); and planting seeds in the pits when rain starts. Similarly, forest zai can be used to combat desertification: the goat dung added to the pits, often full of various seeds (annual plants, bushes and trees), leads to the restoration of a diversified vegetation.

Zai has many advantages. By breaking the soil crust, zai facilitates water collection and infiltration in the soil, thus contributing to limit runoff and erosion. By concentrating water and organic matter in the holes, instead of spreading it over the whole field, it reduces needed input quantities, saves costs, and increases water and nutrient availability for plants. Hence, zai allows the cultivation of highly degraded, quasi sterile lands. However, water and nutrient harvesting must go hand in hand. Improved water availability within the pits is known to increase nutrient uptake and use efficiency. In turn, adequate nutrient supply foster plant growth and root development which facilitates water circulation in the soil, thus reducing plant vulnerability to intermittent dry spells.

In the Sahel, moist and amended zai pits attract termites, which dig galleries fostering deep water infiltration, improving soil structure and facilitating plant roots development. Through comminution and via their excrements, they transform organic matter making it more easily assimilable by the plants.

Zai thus combines very efficient water and nutrient management practices into a technique that requires little external inputs, bears very low costs and requires no extra knowledge or technology, making it easily accessible to and manageable by small and poor farmers. However, one important constraint limits zai uptake and out-scaling: the amount of manual labour required (in the range of 300 hours/ha). However, in the Sahel, if the pits are dug during the dry season, when farmers do not engage in other field activities, labour might be less of a constraint. Moreover, a field experiment in Burkina Faso has demonstrated that animal-drawn mechanized zai can reduce required labour quantity to about one-tenth of the time and further increase yield by one third when compared to manual zai. The use of machine borers could be another way to reduce the workload, but would increase the costs.



The process of forming a zai pocket
Author: Marie Liesse Vermeire | © Educational use, non-commercial.



Zai pit with young millet and cowpea plants.
Author: Dougbedji Fatondji | © Dougbedji Fatondji

/// Always Moving Forward ///

Zai proved very efficient in the Sahel. By improving soil moisture and water retention capacity, fostering amendment decomposition and nutrient release, and facilitating root development, zai can multiply crop yields manifold or even allow cultivation where it was not possible. Zai is best adapted to low fertile drylands (between 300 and 800 mm/year of rain). Zai can rapidly and significantly improve soil structure, thus allowing the progressive revegetation of bare and sterile soils. Not only zai enhances food security and farmer incomes in the Sahel, but it also combats desertification through land restoration and reforestation.

With climate change, aridification is expected to expand in the Mediterranean Basin, particularly in North Africa, Portugal, Spain and Greece: soil and climate conditions in the region will likely come closer to Sahelian current ones. We thus need to adapt zai and anticipate its use in the Mediterranean context as a viable and economic way to revegetate and restore soil productivity in degraded drylands. Zai technique can be further improved through modern machinery use to reduce the workload and improved amendment practices matching better nutrient release with plant growth needs over time. Soil fauna and biological processes would also need further studies to understand how they can fulfill the role that termites have in the Sahel.

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  Published: August 3, 2023. https://theconversation.com/cultiver-sans-eau-ou-presque-la-technique-du-za-au-sahel-210855 (In French)

Authors: Nathanaël Pingault, Christopher Martius, Dougbedji Fatondji | **Partners:** CIFOR-ICRAF – Center for International Forestry Research and World Agroforestry

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ResAlliance

Installation of hedgerows in areas prone to desertification using drought adapted deep rooted plants

In the framework of the EU LIFE-AGROASSIS project, the Department of Forests of the Republic of Cyprus and KES Research Centre developed an innovative protocol to plant resilient hedgerows to combat desertification.



The EU Life project Agroassis targeted the driest areas in Cyprus to develop resilient hedgerows.
Author: Dimitrios Sarris | © Educational use, non-commercial



Deep roots training tubes at the Forest Department of the Republic of Cyprus.
Author: Dimitrios Sarris | © Educational use, non-commercial

/// Context ///

Planting resilient hedgerows in burnt and/or degraded agricultural land is a path proposed by the EU LIFE-AGROASSIS project to combat desertification, coordinated by the Agricultural Research Institute of Cyprus. Within the project the Department of Forests of the Republic of Cyprus in collaboration with KES Research Centre (KESRC) developed a planting system named Deep Root Training Tubes (DRTT). This system's aim is to produce deep rooted seedlings resistant to water stress in the nursery with reduced care requirements in arid environments after planting.

To enhance community engagement and raise awareness about environmental protection from climate change, the project partner Laona Foundation actively recruits and coordinates volunteers from companies and organisations, who following a training in the specialised planting method, contribute enormously to the installation of hedgerows. Hundreds of volunteers from 20 enterprises, academic institutions and other organisations participated in this year's planting events, organised by the Laona Foundation in collaboration with the office of the Cypriot Commissionaire for the Environment and the initiative '300.000 Trees in Limassol'.

/// Solution for a Resilient Future ///

From the 24 plant species initially proposed in the project, it was discovered that the existing possibility of producing propagating material exists for 18 plant species for which the production of seedlings has already started. The availability of seedlings is determined by the amount of seed production of the previous year, derived from wild plants of Cyprus which are utilized by the Department of Forests. The 18 species of plants selected, divided into 3 groups according to their biotype are the following:

Tree species: Pistacia atlantica, Ceratonia siliqua, Olea europaea sylvestris, Prunus dulcis, Cupressus sempervirens.

Shrub species: Pistacia terebinthus, Pistacia lentiscus, Crataegus azarolus, Laurus nobilis, Arbutus andrachne, Quercus coccifera calliprinos, Ziziphus lotus, Bosea cypria.

Herbaceous plants: Thymbra capitata, Asparagus stipularis, Rosmarinus officinalis, Capparis spinosa canescens, Origanum majorana.

Most of the selected plant species have the potential to develop a deep root system as species adapted to drought. These species can be used to improve the environment in desert and semi-desert areas with severe water shortages and areas that have been severely damaged by fires. They also have the potential to support pollinators providing critical ecosystem services.

Considering the Deep Root Training Tube system, to permit deep root growth in seedlings, 60 cm deep tubes are used, compared to the classic pots-bags. Training lasts 90 days according to the protocol designed. The aim is to develop a much longer root system in tubes than in pots, as well as more robust shoots and roots. Thus, seedlings will already be adapted from the nursery to drought conditions with the

aim of saving on irrigation water, while permitting successful establishment in barren and arid lands.

The PVC tubes with dimensions (60 cm per 10 cm) have a volume of 5 litres in topsoil and include soil amendments (Attapulgite – for water retention – and a beneficial microbe complex-Micosat-F-Olivo). The DRTT system consists of two hemispherical sections assembled together with removable tape and has a waterproof removable bottom cover, permitting water only to escape through the top of the tube. The plants are irrigated under a special protocol in order to gradually bring them to water stress conditions. The picture below shows the development of roots in the DRTT system (a,b,c) compared to traditional pots (d,e).

It was decided that the best time for root growth tubes to receive plants should be after the start of the dry season (e.g. June 2023). In this way, extensive rainfall is avoided that could lead to a possible excess of the amount of optimum water inside the containers, as would be the case during the wet climatic season. It also ensures sufficient solar radiation to thermally stress the tubes by allowing water in the surface soil layers within the tube to evaporate. The above practice is critical in reducing upper root system growth and permits root growth deeper into the tube where moisture is protected from solar evaporation. Planting on site needs a specific drilling machine as shown in the picture below.



Comparaison of roots development between Deep Roots Training Tubes and traditional pots.
Author: Dimitrios Sarris | © Educational use, non-commercial



Drilling machine needed for planting deep rooted plants.
Author: Dimitrios Sarris | © Educational use, non-commercial

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In the first year of the LIFE AGROASSIS project, 2000 deep rooted plants have been produced and planted on field. In the next 2 years, 4000 deep rooted plants will be planted each year. A nursery and planting protocol have been designed by the Department of Forests of the Republic of Cyprus and KES Research Centre (KESRC) and the evaluation of onsite results will be shared.

Resilient to drought, hedgerows are a must in combating desertification and for adapting to climate change for agroecosystems of Mediterranean drylands. Adequate supporting mechanisms are still needed to support land owners and farmers in planting resilient hedgerows, taking in account that the planting of deep rooted plants incurs an extra-cost. However, the long term benefits outweigh the cost, when considering the improvement in soil conditions, microclimate, pollinator services, as well as in secondary crop production. Moreover, installing new hedgerows and retaining them is critical for carbon capture and storage, while potentially supporting farmer income through carbon farming. Therefore, the need for promoting the installation of hedgerows using native and drought adapted plants through the Common Agricultural Policy (CAP) is important and can provide multiple benefits for current agriculture and for the generations to come.

Further information

- The project is running up to end of 2026. More information of the EU LIFE AGROASSIS project available on the project's webpage.
- LIFE – AgrOassis: Regenerative approaches for building climate change resilience in EU agricultural regions prone to desertification: www.lifeagroassis.eu (Accessed 17 May 2024)

Acknowledgment / Contribution

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Authors: Dimitris Sarris (KES Research Centre), Stephanie Polycarpou (Laona Foundation), Klelia Vasiliou, Matthieu Jost, Pierantonios Papazoglou, Georges Boustras (European University Cyprus-CERIDES) | **Partners:** EUC – European University Cyprus

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The usage of digital twins for data-based irrigation management

Decision Support Systems can help to minimize water inputs while enhancing productivity. The DIGIREG case study in Catalonia, Spain.



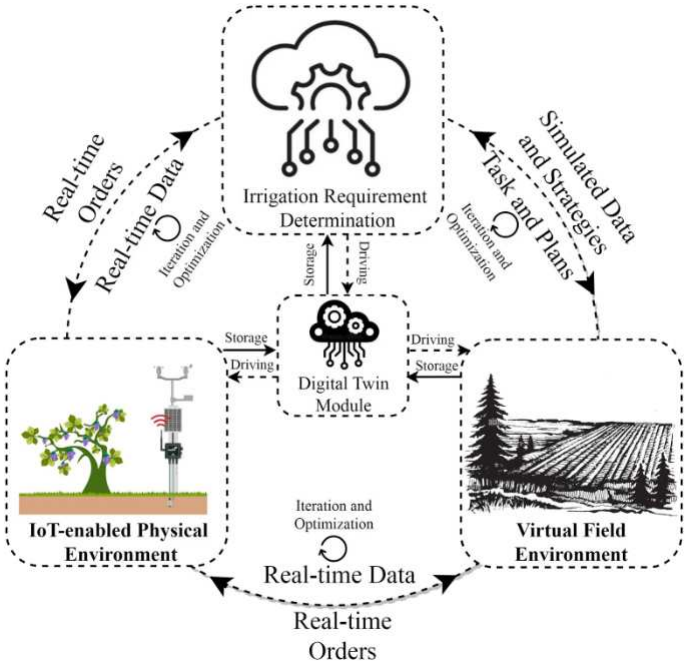
Water is becoming scarce not only in arid and drought areas.
Author: Institute of Agrifood Research and Technology (IRTA).
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/// Context ///

In the actual context, water is becoming scarce not only in arid and drought areas, but also in regions where rainfall used to be abundant. Although approximately 70% of freshwater resources are used for food production, less than 60% of the irrigation water is effectively incorporated by crops. One way to address this issue is to reduce inefficiencies in irrigation management. Key issues in this regard include how to deal with spatial variability and the adoption of deficit irrigation strategies at the field scale.

To achieve this goal, smart technologies related to Decision Support Systems (DSS) such as Digital Twins (DT) are being increasingly utilized for its capability to allow real-time interactions and modifications between the irrigation system and its digital representation. Thus, supporting a precise and low labor management of irrigation. This solution enables to create a virtual replica of the physical irrigation systems, providing a dynamic, data-driven platform to monitor, predict, and enhance irrigation practices. The DT technology's core benefit lies in its ability to provide precise, real-time insights into the irrigation process. By leveraging data from various sources such as soil moisture sensors, weather forecasts, and crop growth models, the DT continuously updates to reflect current conditions. This continuous feedback loop allows for the precise application of water, ensuring that crops receive the optimal amount needed at the right time. The main outcomes include increased water use efficiency, improved crop yields, and sustainable water resource management.

How Decision Support Systems (DSS) can minimize water imputs while enhancing productivity.



Conceptual architecture of an irrigation determination framework.
Author: Manocha, A., Sood, S. K., & Bhatia, M. (2024).
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Digital Twins allow real-time interactions and modifications between the irrigation system and its digital representation.

Farmers can integrate DT technologies into their existing irrigation infrastructure. This can be achieved through the installation of Internet of Things (IoT) sensors and connectivity tools that feed data into the DT model. By doing so, farmers can gain a comprehensive understanding of their irrigation systems, identifying inefficiencies and areas for improvement. For instance, the DT can simulate different irrigation scenarios, helping farmers make informed decisions about scheduling and quantity of water application. This proactive approach ensures that water is used judiciously, conserving resources while maintaining crop health.

By leveraging data from various sources such as soil moisture sensors, weather forecasts, and crop growth models, the Digital Twins continuously updates to reflect current conditions.



Grapevine with a sensor to measure its hydric status in the form of water potential.
Author: Institute of Agrifood Research and Technology (IRTA).
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/// Solution for a Resilient Future ///

Digital twin technology involves the creation of a virtual model that accurately replicates a physical irrigation system. This model is continuously fed with real-time data from various sources:

- Weather Forecasts (e.g. temperature, relative humidity, solar radiation)
- Sensors installed on the ground or on plants (e.g. soil humidity)
- Remote sensing (e.g. crop vigor, evapotranspiration)
- Information provided by the farmer

The DT uses this data to simulate various irrigation scenarios, allowing farmers to make informed decisions about water application. It continuously learns and adapts, improving its accuracy and effectiveness over time.

Implementation Process

- Assessment and planning: Evaluate the existing irrigation infrastructure and identify the specific needs and goals of the farm. Plan the integration of DT technology, including the types of sensors and data sources required.
- Installation of sensors and data collection tools: Install soil moisture sensors, weather stations, and other relevant devices throughout the farm. Ensure these devices are connected to a central data collection system.
- Development of the digital twin model: Create a virtual model of the irrigation system using software that can assimilate the installed sensors and other external sources into soil-crop models.
- Integration and testing: Connect the digital twin model to the data collection system and test its accuracy. Make necessary adjustments to ensure the model accurately reflects the physical irrigation system.
- Training and capacity building: Train farm personnel on how to use effectively the prescription tools powered by the digital twin technology. This includes understanding how to interpret the data and make informed decisions based on the model's predictions.
- Continuous monitoring and optimization: Regularly monitor the performance of the digital twin and the physical irrigation system. Use the insights gained to continuously optimize irrigation practices.

Equipment Needed

Depending on the complexity and scope, the architecture of a DT can be very different. In general, creating and maintaining a DT involves a combination of various machine-to-machine technologies that collaborate to replicate, monitor, and analyze physical objects or systems in a digital environment.

- Soil moisture sensors: These sensors measure the moisture content in the soil at different depths and locations across the farm.
- Weather stations: Comprehensive weather stations that monitor temperature, humidity, wind speed, solar radiation, and rainfall are crucial, providing real-time weather data that impacts irrigation needs. There are different sources available:

  1. Weather stations installed in the farm. May be expensive and require some maintenance. In practice they are only recommend in large farms and where is no other alternative weather station around.

  2. Public weather network accessible online through an API, such as XEMA (Catalonia) or SIAR (Spain). It is a good option if the farm is nearby.

  3. Virtual weather station, offered by several companies, which provide weather data at any point in the planet. It is a good option where is no public network around.



Moisture probes installed in the soil of a productive orchard.
Author: Institute of Agrifood Research and Technology (IRTA).
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Advancing agricultural irrigation through Digital Twin Technology: Implementation strategies and practical insights.

Digital twin technology involves the creation of a virtual model that accurately replicates a physical irrigation system.

The DT uses this data to simulate various irrigation scenarios, allowing farmers to make informed decisions about water application.



DataLogger.
Author: Institute of Agrifood Research and Technology (IRTA).
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- IoT Connectivity tools: The devices should be connected to the cloud of a sensing company and then accessed through the API of their servers.
- Central Data Collection System: This system, often cloud-based, collects, stores, and processes data from all sensors and external sources. It should have robust data management capabilities and provide interfaces for data visualization and analysis.

Depending on the complexity and scope, the architecture of a digital twin can be very different.

- Software for DT modeling: Specialized software that can create and manage the digital twin model. This software should integrate data from various sources into sol-plant models, run simulations, and provide actionable insights.
- Irrigation Control Systems: Automated control systems that can adjust irrigation schedules and amounts based on the insights provided by the DT. If the users have an irrigation controller accessible online through an API, the whole prescription process can be automated. If not, then the user would have to type manually the prescription into the irrigation controller.

Results from Practical Applications

One example of demonstrative approach toward implementing DT technologies in commercial farming systems is the DIGIREG (https://digireg.cat/) project. The demonstration integrates everything from installing sensors, using remote sensing and interpreting all these types of data to optimize and precisely control irrigation, to automatically adjusting the programs in the irrigation controllers. It has different case studies on commercial vineyards and on pistachios, almonds, peaches and horticulture orchards.

/// Always Moving Forward ///

While the advantages of digital twin technology are numerous, there are also a number of challenges that must be addressed in order to successfully implement it. The initial investment required to procure the necessary sensors, data collection tools, and software can be considerable. Complementation of local sensors with remote sensing sources allows to optimize the number of sensors and, hence, to alleviate the initial investments. Another potential solution to this issue is to seek funding opportunities or to implement the technology in phases, thereby spreading the costs over time. In addition, it is recommended that a pilot project be initiated on a limited portion of the farm to evaluate and enhance the digital twin technology before its implementation on a larger scale. Furthermore, the complexity of integrating data from disparate sources that comprise the digital twin necessitates the presence of an overall compatibility and a robust data management system. It is crucial to collaborate with technology providers and to invest in training programs to ensure that individuals involved in farm management are able to utilize and maintain the DT system effectively. It is essential that all relevant stakeholders, including farm managers, workers, and technology providers, are involved in the planning and implementation process. Continuous contact with the technology provider is necessary to ensure that the latest data and technological improvements are incorporated into the DT, thereby maintaining and enhancing its accuracy and

Exploring the challenges and potential of Digital Twin Technology in agriculture: Investment strategies, pilot projects.

While the advantages of digital twin technology are numerous, there are also a number of challenges that must be addressed in order to successfully implement it.

effectiveness. Additionally, the DT requires a period of adaptation to the specific farm conditions, needing regular monitoring and adjustments during this phase.

The utilization of the Internet of Things (IoT) in agriculture has witnessed a notable surge in recent years, while the deployment of digital technologies (DT) in this sector remains in its nascent stages. Furthermore, a number of additional factors, including performance measurements,



Researcher working with the DT.
Author: Institute of Agrifood Research and Technology (IRTA).
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Technician checking measures in the field.
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access to data, operations planning, operations control, and farm characteristics, have been identified as influencing the adoption of technologies in agriculture. Farmers have reservations about allowing a system to operate automatically, given the potential risks to their crops in the event of system malfunction. Consequently, the system must facilitate an evaluation of its performance in a virtual environment prior to undertaking the automated irrigation control of a farm. Once the IoT platform is deployed, farmers may opt for automated control or just to decide for each received prescription whether to transfer them to the controller or decide another irrigation scheduling. When the system is operational, farmers are able to visualize the past, current, and potential future states of their farms by accessing the personalized dashboard and the data stored in the IoT platform. The integration of soil, weather, crop, and irrigation system data enables farmers to receive personalized prescriptions, which can either be applied automatically or be used by farmers to make their own informed decisions , thus enhancing operational efficiency, and reduce water usage in irrigation. As a general guideline, the main role of these systems is to undertake day-to-day

The additional value of DT has yet to be fully realized in comercial farmlands.

The integration of soil, weather, crop, and irrigation system data enables farmers to make more informed decisions, enhance operational efficiency, and reduce water usage in irrigation.

routine decisions (automatically) and let farmers or agronomist concentrate their effort in tactical and strategic decisions (one or few times per year).

The additional value of DT has yet to be fully realized in agricultural applications; however, projects such as DIGIREG are making progress in this area. The potential for DT to be used pervasively, on different spatial and temporal scales, and with varying levels of complexity is dependent on the specific components involved and the desired functionality. The future of DT may evolve from simpler cases, exhibiting fewer compo nents, to more sophisticated ones. As the technology develops, these applications can be enhanced by gradually adding components and functionality, thus showing the full potential of DT.



Efficient water management is essential to overcome desertification and future problems to irrigated crops.
Author: Institute of Agrifood Research and Technology (IRTA)
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Authors: Armand Casadó-Tortosa, Inmaculada Funes and Jaume Casadesús | **Partners:** IRTA – Institute of Agrifood Research and Technology

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ResAlliance

Traditional stone drop structures for water conservation

Revival of a traditional flood control practice to deal with water shortages in small Greek islands.



Construction of a micro-dam with local stones, near Karavas village on the island of Kythira, Greece.
Author: Mediterranean Institute for Nature and Anthropos, and Kytherian Foundation for Culture & Development | © Educational use, non-commercial.



Completed micro-dams ready to receive water.
Author: Mediterranean Institute for Nature and Anthropos, and Kytherian Foundation for Culture & Development | © Educational use, non-commercial.

/// Context ///

Small-scale hydraulic structures were a traditional water management practice applied to the small islands of the Mediterranean since the Minoan era. For centuries, the local community of Kythira island has used various methods to collect water along the torrents of the island, to cope with water shortage during the dry season and to avoid seasonal flooding due to intense rainfalls. This led to the construction of small stone barriers across the stream to control water flow.

These micro-dams (or drops) reduce the slope of the steep streams and collect small amounts of water creating shallow ponds (locally called “Loutses”, in Greek) with the purpose of irrigating adjacent crops and water livestock. Even today, the drop structures are constructed with local materials (stone), providing an easy and cost-effective solution for the local population’s water needs, and an effective tool against the severe flooding episodes faced by many Mediterranean islands in recent years, due to climate change. In addition, the promotion of this environmentally friendly millennia-old practice, apart from its enhanced cultural and aesthetic value, can also provide useful benefits in terms of biodiversity conservation, soil erosion mitigation and groundwater enrichment.

/// Solution for a Resilient Future ///

“Drops” are mild hydraulic structures used to control grade, water levels and flow and to reduce erosion, while achieving natural aesthetic adaptation and demonstrating environmental sensitivity.

In 2021 the Mediterranean Institute for Nature and Man (MedINA) in cooperation with the local community of Kythira started the reconstruction of several stone drop structures along the torrent stream of Patima in the northern part of the island. The main goals of the project were local irrigation and water filtration, biodiversity conservation, and cultural revival that can also act as a tourist attraction. Using the old local traditional technique, a network of 26 stone drops was constructed along 2.7 km of a riparian ecosystem. Using the stones of the area, as the basic construction material, those simple low-cost “micro-dams” have preserved the traditional character of the constructions and are fully in harmony with the environment and the aesthetics of the area.

Drops do not require specialized hydraulic expertise and are created with natural materials from the stream itself. Large, wide stones are placed on top of each other, across the flow of the river and they function as small technical, hydraulic works that interrupt the continuity of water flow. They cause negligible hydro-morphological alteration. The water collected upstream of these constructions creates shallow ponds, small in quantity but very important for the following reasons:

- They provide essential anti-flood and anti-erosion protection, addressing an urgent need intensified by climate change, particularly in the Mediterranean islands. This simple design effectively slows down water flow, playing a crucial role in mitigating floods by retaining substantial water volumes.
- Drops enhance water infiltration and contribute to

aquifer enrichment. The concentrated rainwater in small pods significantly augments the volumes that are infiltrated into underground aquifers.

- The initiative encourages the re-utilization of abandoned crop plots along the stream, providing an ideal irrigation method during the frequent drought periods. The ponds created offer water access points for livestock, wild animals and birds, in addition to making water available for growing crops.
- These shallow pools serve as biodiversity hotspots, as they act as tiny wetlands in the dry, often semi-arid, island ecosystems, providing suitable habitats for various plants, insects and amphibians.
- The stone drops become a tourist attraction, adding to the captivating environment of the small islands, contributing to the restoration of cultural heritage, benefiting local businesses and revitalizing sparsely-populated areas. A good proof is the recently mapped Patima trail which is already drawing nature enthusiasts and hikers.

A weakness of stone drops is that they are not solid enough to resist strong hydraulic loads in case of heavy flooding. Their stability may be compromised by potential erosion of the stream bed and the banks. They need more maintenance than reinforced-cement structures. They cannot avert the risk of intense flooding events. Lack of experienced workers can be a problem.



Small ponds (Loutses) behind micro-dams on Kythira island.
Author: Pavlos Koroneos, Kythira | © Educational use, non-commercial.



A small pond behind a micro-dam (detail).
Author: Pavlos Koroneos, Kythira | © Educational use, non-commercial.

/// Always Moving Forward ///

The enhancement of drop structures can be taken to the next level through implementation of potential improvements. These encompass undertaking a comprehensive new study to enhance the structural integrity of drop structures, exploring innovative designs for increased robustness to withstand heavy water flow conditions. In parallel, establishing frequent visits by local users can act as continuous monitoring of the condition of each drop structure, especially in the aftermath of heavy rainfall events, will contribute to their timely maintenance, ensuring longevity and effectiveness. Moreover, a comprehensive understanding of the environmental impact can be developed by implementing a systematic monitoring framework for ecological (presence of fauna and species), chemical (substances from anthropogenic activities) and hydrological (water quantities) state of the water concentrated in the ponds. It is also crucial to clarify the requirements and the contribution to water consumption of the local water users, such as farmers, to ensure that the drop structures capacity aligns with the specific needs of the local community. Finally, dissemination actions (publications, articles, educational programs, etc.) can spread the practice other places facing similar challenges.

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Acknowledgment / Contribution

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Authors: Institute of Mediterranean Forest Ecosystems | **Partners:** ELGO – DIMITRA – The Hellenic Agricultural Organizations

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Drystone Walling: an ancient practice and a nature-based solution to build land resilience

By combining field studies, material testing, and computational modelling, the study examines the structural integrity and durability of these unique constructions of cultural significance in Cyprus.





Pedoulas Workshop on Drystone Walling, October 2021.
Author: Antonia Theodosiou | © Educational use, non-commercial.



Drystone walls creating plateau's for agriculture (vineyards).
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/// Context ///

Drystone structures in Cyprus present exceptional applications and appearances across the entire range of the landscape. The geological background of Cyprus, with the well-known way of emerging from the bowels of the earth, is characterized by a scattering of rocks and consequently elements of erosion. Locals, and especially those who operate in agricultural/livestock areas, utilized the art of drystone to cope with the rough landscape, creating stability in the soil, managing balanced humidity and microclimate creating favourable conditions for the properties and their crops. Drystone presence is emphatic mostly in the areas of Pitsilia, Solea, Marathasa, Krasochoria (Limassol wine villages), as well as in the Akamas Peninsula.

These last years there have been several efforts, in Cyprus, to bring this traditional treasure to present practice, since the beneficial aspect of the settlements has been well recorded. Under the scope of the 3PRO-TROODOS Integrated Project, relevant workshops have been conducted, local craftsmen have been involved and a technical manual of this ancient practice has been edited.

"Xerolithia" (in Greek "Ξερολιθιά", literally meaning "drystone") is a tailor-made tool, as each and every drystone wall is unique. Stones are placed one by one in layers, without the use of any binding mortar, creating a kind of a stone-net, based only on the rules of physics. Positioning of the drystone wall is selected after a problem or erosion is diagnosed, stones are picked from the same area, and placement is designed according to the local landscape and the needs recorded. At the end, the drystone wall behaves as a unit, totally aligned with its surrounding natural elements.

> **Drystone construction, an ancient building technique that relies solely on strategic placement of stones.**

Drystone walling is considered essential up to date, following discourses on the climate crisis and the need to tackle weather extremes. There are a lot of examples and evidence promoting the beneficial aspect of this art, including indications that it also enhances biodiversity and creates microclimatic conditions that improve agriculture, or that it even creates agriculture terraces in places that without drystone walling it would be unthinkable.

> **Drystone walling enhances biodiversity and creates microclimatic conditions which improve agriculture, or creates agriculture terraces in places where without drystone walling it would be unthinkable.**

> **Stones are placed one by one in layers, without the use of any binding mortar, creating a kind of a stone-net, based only on the rules of physics.**



Biodiversity and plantation are fully supported.
Author: Antonia Theodosiou | © Educational use, non-commercial.



Teisia tis Madaris Nature Trail (Geotrail) supported and preserved with beautiful drystone structures.
Author: Antonia Theodosiou | © Educational use, non-commercial.

/// Solution for a Resilient Future ///

Drystone structures offer a series of solutions which, in addition to being practical, are also environmentally friendly. The uses of the practice find application in both rural and urban fields, thus constituting it as a great and innovative practice which is a nature-based solution.

1. Solutions for Agriculture and land management

Plot delimitation and livestock management structures are recorded and historically have been used to demarcate the boundaries of private property, also to control animals in livestock areas. Their limiting function as boundaries, controls the animals without the immediate need for continuous monitoring. This is seen as particularly useful in the countryside and rural areas, where fencing solutions need to be sustainable, both over time and in terms of supporting biodiversity and the landscape.

1.1. Prevention and prevention of erosion

In areas that suffer from soil erosion, such as mountainous and semi-mountainous areas, dry stone structures are used as a soil retention mechanism that allows the continuation of vegetation, water movement, supports biodiversity, etc. The creation of drystone plateaus in these areas has been an important tool for local farmers, but also a food provider for every home, even if there was no agricultural commercial exploitation.

1.2 Water management

Drystone structures can also support water management. Their structural characteristics they allow the free circulation of water, its proper absorption due to the prohibition of the use of any binding mortar. These valuable properties, in conclusion, were also exploited in cases of flood prevention, thus making the best use of water flows to irrigate crops, but also allowing natural flows to enrich both aquifers and support biodiversity ecosystems.

2. Environmental and Ecological Solutions

2.1 Habitats

The cracks and gaps, left by the construction of drystone walls without binding mortar, allow for various species of flora and fauna to utilize them as habitats, and as places for feeding and reproduction. These microhabitats support biodiversity and provide shelter and breeding ground for insects, small mammals, birds and plants. The fact certainly strengthens the ecological health of the area and the balance of the ecosystem.

2.2 Carbon footprint reduction

The drystone structures are created from natural materials collected locally, thus yielding a significant reduction in the carbon footprint compared to any other proposed solution. Their construction and maintenance require minimal to zero energy, hence identifying it as the most environmentally friendly practice and the best to support it as a Solution that is truly “Nature-Based”.

2.3 Aesthetic and Architectural harmony

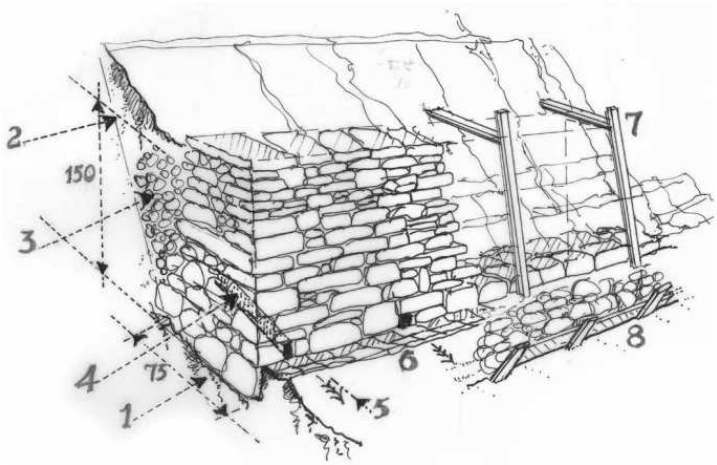
Drystone structures offer physical and aesthetic satisfaction in contrast to synthetic landscapes overwhelmed by cement, iron and rubber. They integrate perfectly into the landscape enhancing and highlighting the natural beauty of parks, gardens and open spaces.

2.4 Reduction of noise pollution

In the urban environment, dry stone structures also act as sound absorbers, thus protecting homes from disturbances from the road network or other vibrations.

Drystone Walling is a multilevel beneficial practice of great importance to nature.

In the event of an earthquake or other shocks, the strategically placed stones, behave as a single body, integrated into the landscape and moving naturally with it.



Implementation method explained in graph.
Author: Antonia Theodosiou | © Educational use, non-commercial.

3. Structural and safe solutions

Dry stone structures function with great safety and durability as retaining walls, both in the urban environment and in the countryside, the mountainous and semi-mountainous areas. Their integration into the natural landscape provides them with “elasticity” and flexibility in movement. In the event of an earthquake or other shocks, the strategically placed stones behave as a single body, integrated into the landscape and moving naturally with it.

3.1 Durability

The inherent strength of drystone structures translates into minimal maintenance care required and a long lifespan. Their construction, requiring adaptation to the natural landscape, makes them resistant to extreme weather conditions, from heavy rain to frost and to extreme heat, thus allowing their beneficial presence to survive if not for centuries, certainly for decades.

4. Economic and Social Solutions

Despite the fact that the implementation of a drystone structure can seem like hard work with several person-hours, the benefits over time are far beyond worthy of its implementation. The durability for decades, the minimal maintenance costs and the multiple benefits definitely work as boosters. At the same time, the inclusion of drystone structures.

Their construction and maintenance require minimal to zero energy, hence identifying it as the most environmentally friendly practice.

In areas that suffer from soil erosion, dry stone structures act as a soil retention brake allowing the continuation of vegetation, water movement, support of biodiversity, etc.

/// Always Moving Forward ///

Given the value of the practice, specific needs for the future are recorded.

Given the value of the practice presented, several specific needs for the future are identified bellow:

1. The need to integrate dry-stone structures for fire protection needs and/or for post-fire restoration projects. It is clear that dry-stone structures, by retaining moisture and maintaining a microclimate through vegetation, act as a brake and retardant for the spread of fires, an extremely useful function given the extreme nature of the phenomena observed in recent years. Any means or tool that can slow down the spread of fire is particularly important in Mediterranean forest ecosystems. In addition, the creation of platforms and the retention and natural circulation of water, foster moisture conditions that can help prevent the start of fires. Regarding restoration projects, the need to support drystone infrastructures against other anti-erosion or anti-flooding projects is noted due to their characteristics: infrastructure flexibility, a solution based on nature: space for growth of microflora and support for insect and micromammal habitats, permeability and simultaneous support of soil and moisture necessary for the rebirth.

2. Incorporation of an obligation to preserve drystone structures and to promote the mandatory application of the technique in all public and private sector projects involving interventions and landscape management actions in all sectors (rural and natural landscape, periphery and fabric of settlements). It is observed in many cases that natural structures are replaced with imported materials and concrete, even in the middle of new settlements. The function of drystone as a world cultural heritage should also find application in the Legislation of the Urban Planning Authority for traditional buildings and settlements.



First steps in implementing a drystone wall – ditch opening for greater stability of the structure.
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Drystone walls serving as fire break corridor.
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3. Prohibition of using cement or other binding mortar in places that are characterized as areas of nature protection, support and protection of biodiversity, rivers, etc. As in point 2, the presence of drystone is important to support or restore biodiversity. Without integrity in the functioning of ecosystems, no resilience or sustainability mechanism can be truly meaningful or beneficial.

4. Establishment and implementation of a program for the gradual conservation, restoration and construction of drystone structures. Establishment and financing of a chamber and school for drystone walling. Preparation of a program of theoretical and practical training and certification of artisans. Cooperation and networking with corresponding bodies/schools abroad. The breadth of issues concerning the value and applications of drystone should be an educational object of further study, utilization and specialization.

5. Creation of a Registry of Artisans and its continuous updating at a state level:

- Recording and mapping of the existing drystone reserve, in parallel with preparation of additional studies and ad hoc/regional manuals, in relation to the

A nature based solution : space for growth of microflora and support for insect and micromammal habitats, permeability and simultaneous support of soil and moisture necessary for the rebirth.

Establishment and implementation of a program for the gradual conservation, restoration and construction of dry-stone structures.

restoration and construction technique of drystone structures.

- Preparation and integration of theoretical and practical learning programs in schools and other educational institutions.
- Provision of generous incentives for the maintenance, restoration and construction of drystone – structures, and quality control of such constructions.
- Establishment of workshops on an annual basis, drystone festivals, etc.



Horizontal construction in layers of irregular larger and smaller stones and gravel.
Author: Antonia Theodosiou | © Educational use, non-commercial.

Prohibition of using cement or other binding mortar in places that are characterized as areas of nature protection, support and protection of biodiversity, rivers.

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Acknowledgment / Contribution

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Small scale weirs for post-fire erosion and flood protection

**Post-fire construction of small weirs for sediment retention and flood protection.
The case of Agios Stefanos, Attica, Greece.**



Check dam construction (back view). Agios Strefanos stream, Attica, Greece.
Author: Ina Daniil (Hydroex SA) | © Ina Daniil (Hydroex SA)



Check dam construction (front view). Agios Strefanos stream, Attica, Greece.
Author: Ina Daniil (Hydroex SA) | © Ina Daniil (Hydroex SA)

/// Context ///

Building weirs and check dams after a wildfire has significant ecological and socio-economic impacts. Ecologically, weirs stabilize slopes, promote vegetation regeneration and enhance biodiversity. Socio-economically, weirs can enhance the infrastructure and human protection from future fires and preserve the local economy. They may even attract tourism. They reduce erosion and long-term infrastructure damage, conserving resources over time, while regulating extreme flood events and sediment relocation within riparian zones.

In the case of the wildfire in the forest near the settlement of Agios Stefanos, Attica, in August of 2009, closely after the event, the study and construction of four control weirs was carried out across the streams that enrich the Lake of Marathon which supplies some of the water Athens uses. This water and soil control practice contributed to the preservation of the minimal surviving vegetation along the streams, control of future flooding events and the protection of the downstream reservoir from excessive sediment relocation. Such post-wildfire small scale hydraulic constructions constitute a mild intervention that contributes to the immediate recovery, and supports a sustainable and resilient future for ecosystems and communities.

/// Solution for a Resilient Future ///

Constructing check dams after a forest fire is crucial for several reasons. They facilitate erosion control which is essential as the lack of vegetation increases, leading to landslides. Sediment retention is vital since eroded soil can obstruct waterways and disrupt ecosystems. Weirs capture these sediments, ensuring water quality and ecological integrity. They promote habitat restoration, supporting wildlife and forest recovery. Additionally, as small-scale water control structures, aid in flood control by managing increased water flow, they retain water, enriching groundwater, and holding nutrient-rich soil particles, promoting plant growth and serving reforestation.

In August of 2009, the forest area of Agios Stefanos, Attica was affected by wildfires. The Agios Stefanos stream drains into Marathon Lake with a catchment area of 7.35 km². The wildfires burned 2.33 km², representing 31% of the basin downstream of the settlement. Within the settlement, approximately 5 acres were burned, mainly in the streambed area. Immediately after the event, the study of the construction of weirs was considered as the most appropriate and was prepared and delivered by Hydroexygiantiki SA in the same year, following a verbal order from the Directorate of Hydraulic Works of the Attica Region. The construction was undertaken by the company ETVO ATE to which the study plans for the construction of these urgent projects were delivered.

In this project, the construction of four check dams of gabions was proposed. Gabions are wired cages filled with rocks and soil that can substitute a landscape element and contribute to erosion prevention and slope retention. The first weir, 3 meters high, was located within the limits of the Municipality of Agios Stefanos, approximately 100 meters downstream from the confluence of another stream. The next two weirs, each 2 meters high, were constructed in sections where there is access from the road and the streambed is relatively narrow. In other sections along the stream the construction was avoided due to widening of the streambed and the presence of cultivated areas, making the area unsuitable. The fourth weir, also 3 meters high, was proposed upstream of the lakeside road, in the stream that flows approximately 200 meters east of the water intake tower (approximately 0.25 km² drainage area). Its size was determined by the site's morphology, as it controls a very small drainage basin and was placed to retain sediments

due to its proximity to Lake Marathon. The proposed locations were selected following on-site visits and based on accessibility for immediate implementation, the morphology of the area, and the size of the upstream basin.

Although the construction of check dams did not have a great impact on peak discharge, they constituted a highly effective protection method. They significantly helped in retaining transported materials and stabilizing the streambed. Slowing the flow and reducing drag force are key factors in their efficiency. Although small gabion weirs are not considered a low-cost solution, they minimally alter the landscape, maintaining the area's aesthetics while supporting flora growth.



Check dam construction (front view). Agios Strefanos stream, Attica, Greece.
Author: Ina Daniil (Hydroex SA) | © Ina Daniil (Hydroex SA)



Check dam construction (back view). Agios Strefanos stream, Attica, Greece.
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/// Always Moving Forward ///

Apart from small dams, other solutions can protect ecosystems after wildfire events. Within prevention framework, spatial planning, using floodplain zoning and avoiding construction in vulnerable areas can minimize risks. Technological solutions like smart monitoring systems provide real-time environmental data for better prevention management, educational campaigns raise awareness, while strict regulations ensure compliance with best practices. Other practices can include wetland restoration, reforestation, raising shorelines and improving drainage systems, that can manage water flow and reduce flood risk. Reforestation stabilizes soils, reduces erosion, promotes habitat restoration and prevents flooding.

Other future strategies could embrace advanced technologies like drones for aerial assessments and integrated water management plans for climate change adaptation which are crucial as changing weather patterns influence fire and flood dynamics. Finally, specialized training programs for local populations in restoration techniques and social participation promotion campaigns could involve local communities in restoration efforts. International cooperation for sharing knowledge of optimal environmental practices and financial tools, could support all the above initiatives.

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On-stream ponds for soil retention on burnt or degraded areas

Post wildfire, the Department of Forests and the Water Development Department of the Republic of Cyprus built stream retention ponds for soil retention, peak flow attenuation, biodiversity support, and ground water recharging purposes.



Construction of gabion on-stream retention ponds post Arakapas fire, 2021.
Author: Kostas Aristeidou | © Educational use, non-commercial.



Gabion pond filled-up with materials from the upper watershed.
Author: Kostas Aristeidou | © Educational use, non-commercial.

/// Context ///

In Cyprus, after the catastrophic fire of Melini-Arakapas in 2021, the following hydrological problems have been raised by the Cyprus Water Development Department (Kostas Aristeidou, Senior Hydrologist):

- Management of increased flood risk in watercourses and rivers.
- Erosion and sediment management in watercourses.
- Loss of useful storage volume of downstream reservoirs from transported erosion material.
- Protection of surface and groundwater water from pollution.
- Effects on water balance of surface and groundwater recharge.

The first issue that the Water Development Department wanted to address was the increased flood risk due to the high vulnerability of the bare soil to erosion. The absence of vegetation on burnt areas generates a lower water retention capacity, thus inducing a quicker runoff, which is expected to increase the flood risk. In addition, due to the absence of vegetation, the risk of erosion is high and the flows are expected to transport increased volumes of materials, which increase the risks of clogging culverts at road intersections and of related damages caused by the flood. Furthermore, it was expected that some of the sediments would runoff up to one of the dams, reduce its storage capacity, and affect the quality of its water which is used as a drinking water supply.

/// Solution for a Resilient Future ///

On-site visits were conducted, with all the relevant competent Departments of the Republic of Cyprus and with accompanying Experts both from Cyprus and abroad (e.g. the University of Athens and Expert in natural disaster management Professor; Dr. Efthymios Lekkas). Upon completion of these visits, it was decided that in the area in question, taking into account the conditions and available materials, the management of flows and of the flooding-risk will be done through the construction of small embankments with wire boxes filled with rocks (gabions) in the watercourse beds, with priority in the upstream areas with a steep gradients where the potential of erosion is high.

In this way, erosion control is achieved, since the transported materials will be trapped by the embankments and will be held upstream of the basin. Significant loss of soil is thus prevented, as well as the transport of large volumes of materials to the downstream Kalavasos reservoir, which would have induced a hardly recoverable loss of useful volume.

In addition, it was decided that the location of the ponds must be on registered watercourse beds or other state land. Furthermore, there should be an easy access to the construction sites, to avoid disturbance of the vulnerable burnt soil by the entry of heavy machinery into burnt areas off the road network. The ponds should also be located upstream of roads to protect the roads from being blocked by transported materials from floods.

In order to identify the positions that meet the above criteria, the following procedure was followed, utilizing Geographic Information System:

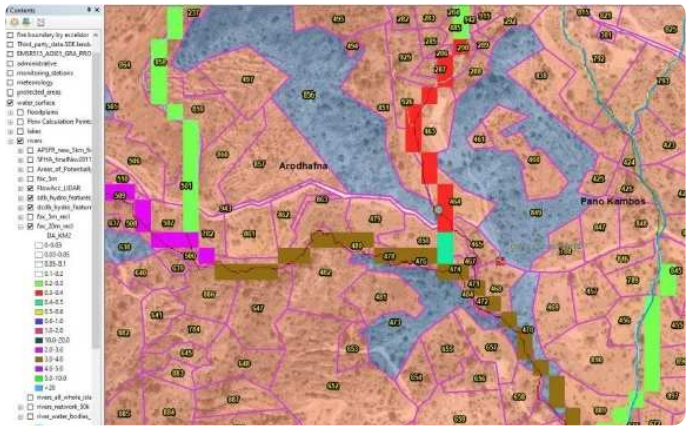
- It was assumed that the minimum catchment size, which can accumulate a flow causing significant problems of erosion, important supply of transported materials, and flooding, is 0.3 km2.
- The hydrographic network was determined from ground elevation models, and in combination with the boundaries of the burned area and aerial photographs, to locate the road network and the registered watercourse beds and state land.

- The location of the proposed ponds in areas that were not registered beds was more accurately determined using the elevational relief and the 1m-LIDAR hydrographic network.
- Other sites downstream of watercourses were also selected, so that each site covered at least an area of 0.3 to 1 km2 of burned watershed without pond.

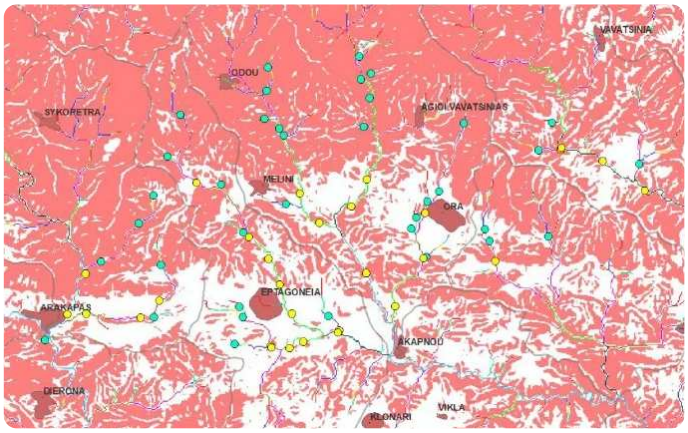
Based on the above procedure, 66 candidate pond/ embankment sites were determined, with a catchment area that varied from 0.3 km2 up to 23 km2.

As confirmed with all stakeholders, first priority was given to small ponds/embankments upstream of watersheds, in areas with steep gradients, to contain runoff on steep slopes and prevent flooding upstream. These ponds could be made quickly, due to their small size, to prevent any extreme weather events in Autumn.

In the next phase, with more time for more in-depth studies and investigations, larger embankments can be made downstream, in larger catchment basins, and with a gentler ground slope. Such large embankments could also be used as enrichment dams, upon evaluating the response of the upstream embankments (after the first flood flows and sediment transport that will happen). On this basis, 37 first priority sites were selected.



Selection of sites on government land (blue) in an area where there was no registered watercourse, Arakapas fire 2021.
Author: Kostas Arissteidou | © Educational use, non-commercial.



Ground slope above 30% (red color) and definition of 1st priority embankment (blue), Arakapas fire 2021.
Author: Unidentified | © Educational use, non-commercial

/// Always Moving Forward ///

The loss of vegetation is expected to lead to greater surface runoff and less infiltration and enrichment of groundwater. The construction of the proposed ponds/embankments, especially in the large catchment areas downstream, is expected to help in the enrichment of groundwater if the ponds are placed in suitable positions to perform adequate recharge.

In addition to this gabion-technic to facilitate soil retention on burnt or degraded areas, the Water Development Department of the Republic of Cyprus is also facilitating the following measures:

Creation of small off-stream retention ponds, for peak flow attenuation, biodiversity support, and groundwater recharging purposes, with the use of lateral weirs or diversion structures that will divert water only during flood events.

Controlled flooding of agricultural, state and forest land in the flood plain, with the use of lateral weirs or diversion structures that will divert water only during flood events.

On-stream (at the very upstream of catchments) and off-stream terracing, for retaining stormwater and preventing erosion in agriculture fields. This is a traditional practice implemented for hundreds of years in Cyprus and Greece.

These measures are part of the 2nd Flood Risk Management Plan of the Republic of Cyprus (1).

Further information

- For more information, contact Kostas Aristeidou, Senior Hydrologist from the Water Development Department of the Republic of Cyprus.
- Water Development Department of the Republic of Cyprus. 2023. Second Flood Risk Management Plan of the Republic of Cyprus. URL : https://www.moa.gov.cy/moa/WDD/wfdf.nsf/page11_gr/page11_gr?opendocument (in Greek)

Authors: Kostas Aristeidou (Water Development Department of the Republic of Cyprus), Klelia Vasiliou, Matthieu Jost, Pierantonios Papazoglou, George Boustras (European University Cyprus – CERIDES) | **Partners:** EUC – European University Cyprus

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Accelerating the recovery of plant cover after post-fire salvage logging by piling woody debris

In burnt and salvage logged Mediterranean pine forests, the presence of seed-dispersing birds and subsequent vegetation colonisation is enhanced by the presence of woody debris built during restoration interventions.



Figure 1. An area where woody debris piles were built.
Author: Alex Rollán and Joan Real
© courtesy of Equip de Biologia de la Conservació-Universitat de Barcelona.



Figure 2. Piles made in April 2017 with burnt branches in a stone pine forest with burnt cork oaks in July 2016.
Author: Pere Pons | © courtesy of Universitat de Girona.

/// Context ///

Prior to the current high demand for wood for energy purposes, salvage logging after fires only harvested the trunks, leaving the branches in the burnt area. With the current growth in demand for biofuels, the whole tree is usually harvested less than a year after the fire, exploiting virtually all of the burnt aerial biomass. This massive extraction represents an immediate second disturbance, particularly intense when salvage logging leads to clearcutting and the forest is transformed into a fine-grained mosaic of grassland and shrubland.

Plant dispersal and colonisation are important processes in post-fire vegetation recovery, that reduces the time that bare soil is exposed to erosion by rainfall. For several plant species, dispersal and colonisation depend on the presence of frugivorous avian seed dispersers. Post-fire shrubland is only suitable for lowland dispersers after significant vertical vegetation regrowth. Therefore, changes in the abundance and distribution of dispersers in recently burnt environments may hinder seed dispersal of fleshy-fruited plants, whose regeneration in burnt habitats is limited to resprouting or germinating from a seed bank, with limitations on recruitment of individuals from distant areas.

In burnt and salvage logged Mediterranean pine forests, vertical regrowth of vegetation to attract seed dispersers can be mimicked by the construction of woody debris piles, usually used as erosion barriers (Figures 1 and 2), which become seed dispersal foci.

/// Solution for a Resilient Future ///

The management of non-commercial woody debris (branches and the thinnest logs) appears to be a key issue for the persistence of avian seed dispersers in burnt and logged pine forests. When woody debris is not completely removed from the burnt area, it may be left scattered on the ground, or in some cases piled up as log or branch erosion barriers to aid the restoration process. The construction of such barriers is a relatively rare practice in burnt and felled pine forests in the Mediterranean. However, piles made up of logs and branches are an important microhabitat for frugivorous birds, which use them for foraging, perching and sheltering even very soon after the fire, when vegetation regrowth is just beginning. Frugivorous birds use these piles of branches more than any other structure in the habitat (ground, shrub layer, burnt trunk or live pine).
Areas with more piles support more frugivorous birds and more species.

This behaviour of frugivorous birds is behind the high density of dispersed seeds and plant species found under the piles in burnt and logged forests, which is higher than the density found in the burnt areas outside the piles (Figure 3), but similar to that found in unburnt forests. The role of woody debris piles as seed dispersal foci suggests important consequences for the distribution of dispersed species in burnt areas, as frugivorous birds can disperse seeds from plants with fleshy fruits consumed outside the burnt perimeter into it. In fact, the effect of these piles is independent of the distance from the unburnt forest.

If a significant share of dispersed seeds can be successfully established, this microhabitat-dependent seed rain may result in more individuals of bird-dispersed species being found in woody piles than in other microhabitats, which could mean a future heterogeneous plant distribution in areas with woody piles. On a broader scale, this would indicate that burnt and logged areas where such piles have been established may support more diverse plant communities than areas without these structures. Furthermore, considering that dispersed plants produce fleshy fruits that are consumed (and dispersed) by several animal species, the effect of building woody piles may have implications at the ecosystem level. However, the establishment of dispersed seeds under piles will depend on several post-dispersal factors.

The presence of woody debris piles is favourable to the abundance of, at least, Rubia peregrina, Asparagus acutifolius and Rubus ulmifolius, species that are likely to be much less abundant in the absence of piles, especially on southern and south-eastern slopes. After a fire, the soils on the southern slopes are less suitable for seed germination because of more arid conditions. Due to the presence of piles, the cover of bird-dispersed plants in piles on southern slopes was almost as high as on northern slopes without piles.

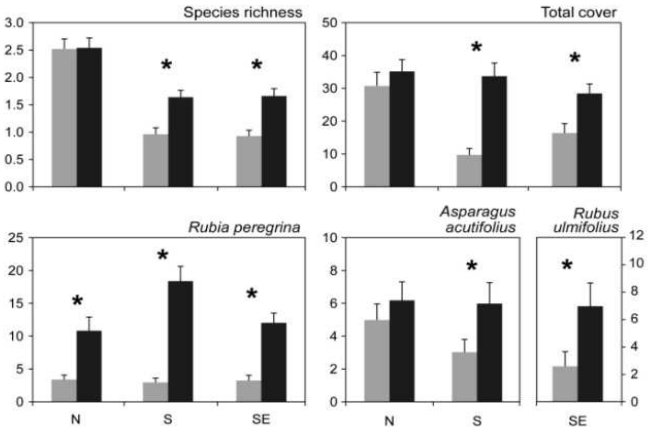


Figure 3. Mean richness, total cover and covers of three plant species outside of piles (grey bars) or within piles (black bars), on each slope (N: north, S: south and SE: south-east). Error bars: standard error; asterisk: significant effects.
Author: Josep Rost | © courtesy of Universitat de Girona.

Taller piles have a greater effect on fleshy-fruited species richness and cover (Figure 4), as taller piles may maintain better microenvironmental conditions for seed germination than shorter piles.

It is recommended to build at least 20 piles or faggots of woody debris per hectare to increase the chance that the burnt area will support a greater richness and abundance of frugivorous bird species. The piles or faggots should be between 40 and 80 cm high, and distributed mainly on the south-facing slopes of the logged area.

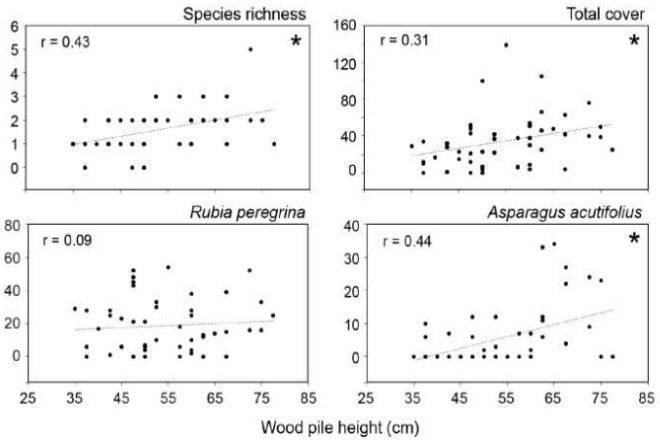


Figure 4. Effect of wood pile height on richness, total cover and covers of Rubia peregrina and Asparagus acutifolius, on southern slopes. Significant relationships ($p<0.05$) are shown with an asterisk.
Author: Josep Rost | © courtesy of Universitat de Girona.

/// Always Moving Forward ///

The creation of woody debris piles as erosion barriers plays a second role: post-fire vegetation recovery by promoting the dispersal and colonisation of plant species dependent on frugivorous avian seed dispersers. It is therefore highly recommended to include the creation of woody debris piles in the management and restoration strategies of burnt and felled Mediterranean pine forests. National or regional post-fire salvage logging regulations should minimise the harvesting of branches and encourage the creation of debris piles. These piles could be located on the top of log erosion barriers, and built at the same time. The logs must be positioned perpendicular to the slope and be in contact with the ground along their entire length. If there are gaps between the log and the ground, rainwater will flow and the barrier will not fulfil its function.

The practice presented here illustrates the results of the only study of how debris piles influence the dispersal and colonisation of plant species dependent on frugivorous birds. It was carried out in north-eastern Catalonia with bird and plant species characteristic of the area. Similar experiments should be replicated in other areas of the Mediterranean to increase knowledge of the benefits of woody debris piles for post-fire vegetation recovery.

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Acknowledgment / Contribution

The content of this factsheet is an excerpt of the doctoral thesis by Josep Rost Bagudanch The effect of post-fire forest management on bird fauna and seed dispersal by frugivorous birds, defended in 2011 at the University of Girona, supervised by Dr Pere Pons Ferran and Dr Josep Maria Bas Lay.

Authors: Eduard Mauri, Josep Rost, Josep M. Bas, Pere Pons | **Partners:** EFI – European Forest Institute

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Reforestation of arid or semi-arid mountain areas in the Jezzine region, Lebanon

The plantation of Lebanese native species is bringing ecosystem and socioeconomic landscape resilience.



Biodiversity in the restored site.
Author: Elie nazih Hedwane | © Jouzour Loubnan.



Tawmet jezzine reforestation site.
Author: Jouzour Loubnan association | © Jouzour Loubnan association

/// Context ///

Lebanon faces a critical challenge in reforestation. Vital native woodlands and ecosystems are vanishing at an alarming rate, jeopardizing the very foundation of our environment. These irreplaceable areas serve as havens for a tapestry of biodiversity, from majestic cedars and soaring eagles to industrious insects and vibrant wildflowers. They are also our allies in the fight against climate change, acting as natural carbon sinks that absorb harmful greenhouse gases. Additionally, healthy forests act as shields against desertification, preventing the encroachment of barren landscapes. Their root systems play a crucial role in soil health, promoting water infiltration and preventing erosion. This, in turn, ensures sustainable water resources and fertile land for agriculture.

Often overlooked in conventional reforestation initiatives, arid or semi-arid mountainous regions areas hold immense potential for impactful restoration. Therefore, Jouzour Loubnan has chosen to implement a reforestation initiative in the semi-arid region of Toumet Niha – Jezzine, an initiative that will have a significant ripple effect, creating invaluable socio-economic benefits for the region and serving as a model for future reforestation projects throughout Lebanon.

/// Solution for a Resilient Future ///

The success of this reforestation project resides through three interconnected goals within the scope of the programme:

1. Increase the woodland area and participate in the restoration of its degraded high mountain ecosystem in close partnership with the Municipality of Jezzine. The project involved planting nearly 40,000 native Lebanese seedlings, encompassing a diverse range of species. These included Ostrya carpinifolia (Hop Hornbeam), Abies cilicica (Cilician Fir), Fraxinus ornus (Manna Ash), Cupressus sempervirens (Italian Cypress), Pistacia palaestina (Palestine Pistachio), and many more. Notably, over 4,000 seeds of Quercus calliprinos (Evergreen Oak), Quercus infectoria (Aleppo Oak), and Cedrus libani (Cedar of Lebanon) were also sown directly. Broadleaf trees, particularly well-suited to the planting site's conditions, formed a significant portion of the planted species.
2. Promote environmental awareness, engaging youth, local residents, and influential stakeholders. This included five national awareness campaigns, reaching a broad audience across Lebanon. Additionally, nine tree-planting events brought together over 300 participants, fostering a sense of ownership and community spirit. Furthermore, four local awareness sessions specifically targeted over 400 Jezzine students, educating the next generation about the importance of protecting Lebanon's natural resources and forests. These initiatives resonated deeply with the local community, leaving a lasting positive impression and fostering a sense of gratitude for the project's efforts.
3. Empower the Jezzine Municipality and local community for long-term success. This involved a series of six workshops and capacity-building trainings held at the municipality. These workshops covered crucial aspects of project sustainability, including:

- Developing Viable Ecotourism
- Fire Prevention and Weeding Techniques
- Successful Reforestation Project Management
- Site Monitoring and Management
- Geographic Information System (GIS) Mapping
- Communication Strategies in Reforestation
- Ensuring the enduring success of this project and safeguarding the planted trees is paramount. To achieve this, Jezzine municipality has played a pivotal role. By endorsing and taking ownership of the initiative, they have committed to its protection and maintenance even after the initial project funding has been exhausted. This long-term commitment goes beyond mere words; the municipality, in collaboration with Jouzour Loubnan, will actively pursue the official designation of Toumet Niha – Jezzine as a Lebanese nature reserve. This crucial step will provide the area with permanent legal protection, ensuring its continued conservation for generations to come.

Furthermore, Jouzour Loubnan recognizes the invaluable knowledge gained throughout this project. They are committed to sharing these valuable lessons learned with a wider audience. Through collaborative discussions with other reforestation initiatives across Lebanon, along with concerned stakeholders like government agencies, environmental NGOs, and local communities, Jouzour Loubnan aims to disseminate best practices and foster a knowledge-sharing network. This collaborative approach will empower other efforts, maximizing the overall impact of reforestation initiatives throughout the country.
By openly sharing successes and challenges, Jouzour Loubnan hopes to inspire and equip others to replicate their achievements, ultimately accelerating Lebanon's journey towards a greener future.



Fir seedlings thriving in the site.
Author: Jouzour Loubnan association | © Jouzour Loubnan association



Jezzine landscape and reforestation site.
Author: Jouzour Loubnan association | © Jouzour Loubnan association

/// Always Moving Forward ///

The project's initial stages were met with unforeseen challenges. Most critically, the presence of landmines necessitated collaboration with the Lebanese Army, the Lebanese Mine Action Center, and local authorities. Thanks to their expertise and dedication, this hurdle was successfully overcome, ensuring the safety of all involved.

Another significant challenge arose from uncontrolled grazing by livestock. Despite signed agreements, herders' continued access to the planting site threatened the young trees. Jouzour Loubnan responded with innovation, pioneering the "individual fencing technique" for the first time in Lebanon. This new approach proved highly effective, exceeding initial expectations and safeguarding the reforestation efforts.

The socio-economic benefits of reforestation initiatives in Lebanon are equally compelling. Restored forests can create new opportunities for ecotourism, attracting visitors eager to experience the beauty and serenity of nature. Local communities can benefit from the creation of jobs in planting, maintenance, and sustainable forestry practices. Furthermore, healthy forests can improve air and water quality, leading to a healthier population and a more attractive environment for businesses and residents alike.

Toumet Niha – Jezzine plantation project was executed in partnership with the Ministry of Agriculture under the Agriculture and Rural Development Programme (ARDP) and was co-financed by the European Union and Jouzour Loubnan Association.

Further information

- Toumet Niha –Jezzine, project and site description. https://www.jouzourloubnan.org/plantation-site-southlebanon/2019/11/8/toumet-niha-jezzine (Accessed 14 August 2024)

Authors: Elie Nazih Hedwane, Rhea Kahale | **Partners:** JL – Jouzour Loubnan

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Evaluation of the effect of individual tree fencing on restored site biodiversity

In Kfadebian, Lebanon, fencing is being applied for landscape restoration against overgrazing.

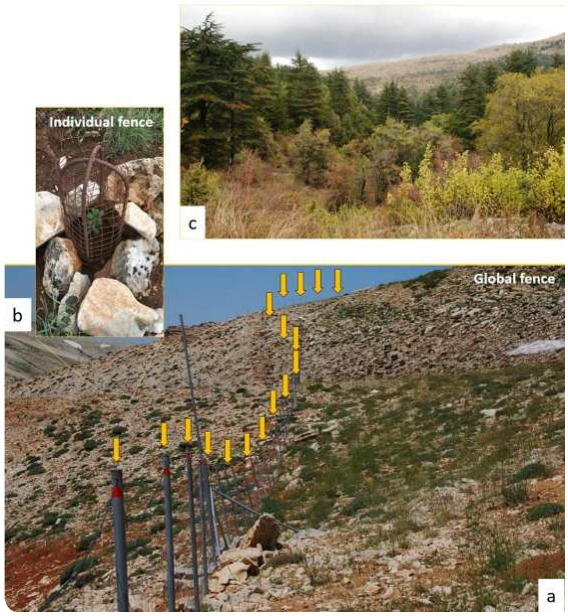


Figure 1. A: Fenced site. B: Individual fences. C: Non-fenced site. All sites are located in Kfardebian, Lebanon.
Author: Rhea Kahale | © Jouzour Loubnan

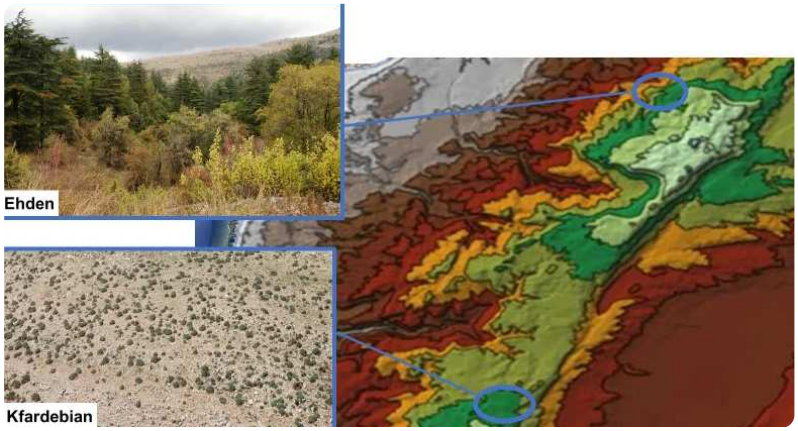


Figure 2. Degraded site (Kfradebian) and reference site (Ehden) in Mount Lebanon. | Author: Jouzour Loubnan | © Jouzour Loubnan

/// Context ///

Lebanon has seen many reforestation projects since the early 1960s, but these efforts were hampered by more than 30 years of war. Recently, the Lebanese government launched a national initiative, led by the Ministry of Agriculture, to plant 40 million forest trees on public land over the next 20 years. All environmental NGOs are invited to participate in this project. Since 2007, the NGO Jouzour Loubnan has entered the field, building on the successes and failures of traditional approaches to reforestation and introducing new, globally accepted approaches based on ecosystem restoration.

Jouzour Loubnan and the Faculty of Science – Saint Joseph University of Beirut have signed a Memorandum of Understanding (MoU) to work together to optimise plantation techniques, reduce costs and improve processes through research and development adapted to the local context. One of the main areas of collaboration is to unravel the relationships between foundation species, associated organisms and their genotypes, and the implications of these relationships for the successful establishment of diverse and viable tree populations.

One of the approaches being tested and evaluated is the effect of fencing on the biodiversity of restored sites. Species richness has been analysed inside and outside the fenced areas, showing that these techniques protect the planted trees, but also favour the overall diversity of the site by increasing vegetation cover, height, biomass production and litter.

/// Solution for a Resilient Future ///

A reference site in the broadest sense is an ecosystem that serves as a model for restoring another ecosystem. They can be less disturbed places close to the restoration site or more distant, if they occupy similar topographic positions when the restoration site is an isolated fragment. A reference site is similar in successional stage, structure, and function, which provide more defined design parameters. This is especially important when the site to be restored is highly disturbed and lacks any biological legacy. This is the case of Kfardebian sites where historical tree cutting and continuous overgrazing led to a depleted soil with poor vegetation. For this project, and in order to identify biodiversity-related success factors of ecological restoration projects, we choose Ehden Nature Reserve as reference site since it fits all of the criteria mentioned above.

This reference site will help us elucidate the animal-plant relationship; promote the reoccurrence of wildlife and the natural regeneration in the pilot site. Within this reserve there is a mixed coniferous forest of *Cedrus libani* and other tree species. *Cedrus libani* and *Juniperus excelsa* stage is at the same altitude and same precipitation rate as Kfadebian site. We have listed all the species of trees and shrubs present there. For ecosystem restoration projects, conifer species are the pioneer species able to develop under harsh environmental conditions such as poor soil, absence of shade more than 7 months of drought and very cold winter. At a later stage, when abiotic conditions will be less harsh, broadleaves species will be introduced. Meanwhile, germination protocols for all these species are developed in the laboratory for seed germination and conservation "Jouzour Loubnan" at the Faculty of sciences Saint Joseph University.

We relied on a unique opportunity to test in-situ a set of parameters affecting plant and animal biodiversity interactions under three different situations, using a 50 hectares site globally fenced since 2009 (site A; Fig 1A), and

another adjacent site where planted trees are fenced individually (site B; Fig 1B) in Kfardebian-Mount Lebanon. The reference site, the Ehden Nature reserve, was situated at the same altitude and developing under similar climatic conditions, protected since 1992 (site C; Fig 1C).

Only 40 species were observed in the 6 studied plots during the present study:

- 20 species were found only in plots 1, 2 and 3 (Fenced site: A). This includes many endemic species threatened by extinction such as *Viola libanotica* and *Puschkinia scilloides* var. *libanotica*.
- 3 species were found only in the site B outside the fenced plot. These species could have been carried to the site by the goats and sheep that roam on different sites in the mountain.
- 17 species were found inside and outside non-fenced plots. These species seem to challenge overgrazing, being dapted to grazing by developing survival strategies such as the accumulation of toxic components or by harboring thorny elements.

Lebanon Mountain is known for its richness in endemic species: *Aubrietia libanotica* occurring only on the rocky cliffs, *Acantholimon libanoticum* and *Berberis libanotica* are both present inside and outside the fence. *Berberis libanotica* is very frequent wile *A. libanoticum* is rare.

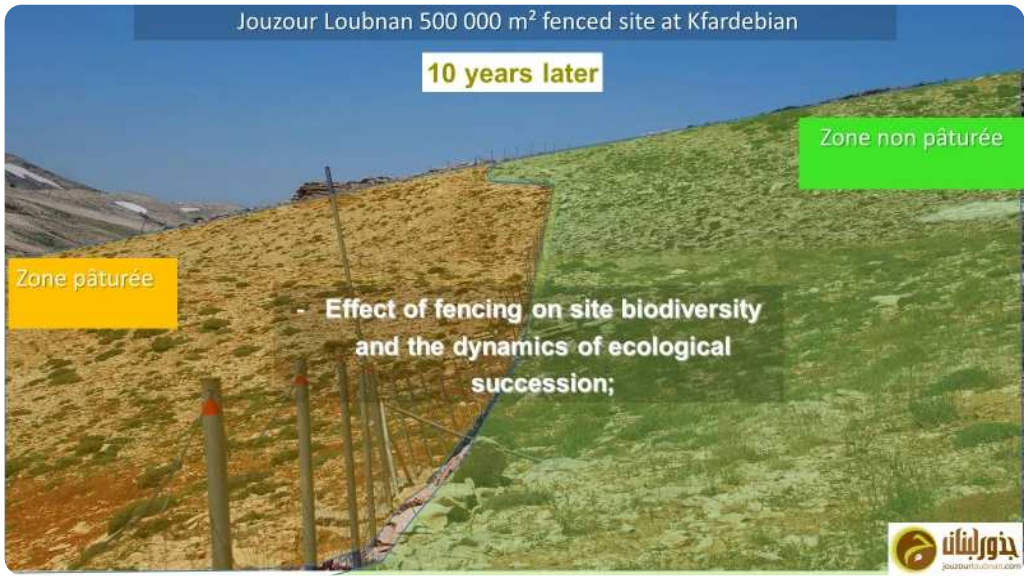


Figure 3. Fenced and non fenced areas in degraded site
Author: Jouzour Loubnan | © Jouzour Loubnan

/// Always Moving Forward ///

The next critical steps in assessing the role of fencing in ecological restoration are to conduct comprehensive surveys of flora inside and outside fenced areas over multiple years and seasons. This longitudinal approach is essential to understand the long-term effects of fencing on plant communities and ecosystem dynamics. By comparing the composition, abundance and diversity of flora inside and outside fenced areas, researchers can assess the effectiveness of fencing in promoting plant regeneration and biodiversity conservation.

In addition, soil assessment is essential to fully understand the physico-chemical properties of the soil inside and outside the fence zones. Analysing soil characteristics such as pH, nutrient content, moisture and texture can provide valuable insights into how fencing affects soil quality and fertility. By comparing soil properties between fenced and unfenced areas, researchers can assess the extent to which fencing affects soil health and ecosystem functioning. By integrating flora surveys and soil assessments, researchers can gain a comprehensive understanding of the ecological effects of fencing in restoration projects. This knowledge can inform evidence-based management strategies aimed at maximising the effectiveness of fencing in promoting ecosystem recovery and biodiversity conservation.

Further information

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Authors: Rhea Kahale | **Partners:** JL – Jouzour Loubnan

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Type of solution: Technology Sector: Forestry
Good practice(s): Protection against biotic and abiotic hazards

A plant nursery protocol to produce Phytophthora-free cork oak seedlings

Ensuring the production of healthy woody plants for forest restoration projects in Sardinia, Italy.



Cork oak forests in Northern Sardinia. If affected by Phytopthora spp. they are more prone to the effects of climate change and cork oak decline.
Author: Sara Maltoni | © Agency FoReSTAS



Nurseries: growing plants on benches aboveground (right) reduces the chances of contamination by Phytopthora spp. compared to benches on the ground (left).
Author: Sara Maltoni | © Agency FoReSTAS

/// Context ///

Species of the oomycete genus *Phytophthora* are well-known pathogens that cause damaging diseases of forest trees and agricultural crops worldwide and are strongly associated with the decline of oak trees in Mediterranean ecosystems. Affected plants often showed symptoms such as crown thinning, chlorosis, and decay caused by extensive fine root loss and/or collar rot.

In a study conducted in 23 European countries in 2015, *Phytophthora* taxa were recorded in 91.5% of nurseries and 66.0% of forest and landscape planting sites. *Phytophthora* species were also detected in Italian nurseries, including those dedicated to the production of plant material used for forest restoration.
Since eradication of these pathogens is difficult, prevention of their introduction through the use of pathogen-free plant material is the most efficient and cost-effective approach to prevent forest decay. To address the need for pathogen-free for reforestation projects, a forest nursery management method has been developed to produce Phytophthora-free plants. The method was developed in a model nursery and consists of a mix of management techniques, best practices and training of employees, and resulted in the production of phytophtora-free propagation material.

/// Solution for a Resilient Future ///

A hazard analysis to determine all potential sources of contamination for *Phytophthora* species is crucial to define the best management solution. A protocol to produce plants free of *Phytophthora* was developed by a team of professionals and scientists belonging to the University of Sassari and the Sardinian Regional Agencies AGRIS and Fo.Re.S.T.A.S., within the Phytosanitary Forest Monitoring Center project. The protocol includes the following tips:

- Start with healthy propagative material, free of infection or external contamination by *Phytophthora* species as well as other possible pathogens. Seeds are collected if possible in certified seed forests, for plants reproduced by plant parts, these come from nursery-born plants grown following this protocol..
- Raise containers off the ground with benches up to one metre and add a gravel barrier between containers and the ground to reduce the risk of contamination from potentially infected soil. Gravel avoid water stagnation in the soil, as *Phytophthora* grows in puddles of water and high temperatures.
- Use new, clean or disinfected containers, as used pots may contain *Phytophthora* spores. Special attention is paid to storing the phytocontainers indoors, away from sources of contamination
- Perform heat treatment of the potting media (soil) using steam, as it is lethal to most plant pathogenic fungi and *Phytophthora* but does not kill all soil microorganisms and will not result in “sterile” soil. The procedure involves mixing plant soil, peat, perlite, and pumice est. Mixing is done with an automated machine that saves considerable time.
- Once mixed, the substrate undergoes steam sterilization that reaches temperatures of up to 120 degrees, substrate that is loaded into a box and covered with heat-resistant cloths, inside of which is a series of steel pipes with perforations that allow steam to diffuse evenly into the mixed substrate.
- Irrigate using deep well water, or implement a water filtering system to avoid contamination, Groundwater is used once analyzed, as public water was heavily contaminated. Filtration systems may be a solution, but they must be carefully maintained on time to ensure their proper functioning
- Adopt disinfection measures of footwear and tools at the entrance to the plant growing area, as cleaning procedures to prevent spreading *Phytophthora* propagules. The work tools are for the exclusive use of the model nursery productions
- Monitor disease symptoms typical of *Phytophthora*, such as wilting, leaf necrosis (browning), chlorosis (leaf yellowing),

dieback, root and collar rot, and sudden plant death are of particular concern, for immediate intervention. Treating *Phytophthora* contaminated plants is impossible, plants showing signs of disease must be destroyed

- Inform and train all nursery staff to learn about potential hazards and comply with the protocol and all best management practices. staff working in the nursery have been trained to ensure the utmost care in the application of Phytophthora-free plant production protocol

This protocol can be replicated in other nurseries to increase plant biosecurity with positive implications for forest and semi-natural ecosystems.



Plants are grown in containers raised above the ground in order to avoid contact with moist soil. soil waterlogging is eliminated by physical barriers, gravel or synthetic sheeting.
Author: Maurizio Frongia | © Agency FoReSTAS



Sowing in heat-treated potting soil in the nursery of Campulongu (FoReSTAS).
Author: Gianni Pili | © Agency FoReSTAS

/// Always Moving Forward ///

As forest nurseries represent the major pathway of introduction of exotic and invasive *Phytophthora* species in Mediterranean countries, EU directives on urban forestation and forest restoration underline the importance of producing plants free of pathogens. Developing new technologies for preventing and controlling *Phytophthora* diseases is then a key to reduce cork and other oak decline or tree dieback.

Currently, the implementation of this innovative plant production strategy, based on the presented protocol, has been limited to a portion of a public forest nursery managed by the FoReSTAS Agency. In order to set up this pilot nursery, large investments have been made and the type of management also resulted in increased operating costs. More than ten different Mediterranean species are highly susceptible to *Phytophthora* grown during the two years of nursery production, only one seedling of M. communis was found positive during monitoring in the first year, while in the second year no *Phytophthora* was isolated from the 10,000 plants grown in the second year, with more than 100 tests conducted.

To effectively prevent the introduction of pathogens into forest ecosystems, the approach presented should be adopted by nurseries linked to reforestation projects. The dissemination of this good practice has been carried out under the Livingagro ENI CBC MED project throughout the Mediterranean, including MENA countries. The practice is currently being further developed and disseminated under the LIFE FAGESOS project.

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Lauricide-Bio biopesticide is a sustainable bioproduct in North Africa

Lauricide, natural biopesticide used in green-house and fields by growers.



Production intrants bio: A.S.Y.Z AGRI/Environmental safety and host specificity are the main benefits of biopesticides in managing agricultural pests.
Author: Walid Sanaoui | © Walid Saaoui



New local bioproduct for ameliorative effect of plant production depending on physiological stage of the plant.
Author: Walid Saanouni | © Walid Saanouni

/// Context ///

As agricultural productivity is weather- and climate-dependent, climate change poses multiple challenges to agricultural activities. The negative impacts of climate change are expressed in terms of reduced crop yields and area, impacts on biotic and abiotic factors, and economic losses. For almost 20 years, climate change has significantly altered the terrestrial ecosystem, resulting in the loss of several species, an increase in fungal and viral diseases and harmful soil parasites that are resistant to pesticides by causing massive plant mortality. Plant disease outbreaks pose significant risks to global food security and environmental sustainability worldwide, resulting in loss of productivity and biodiversity, with negative impacts on the environmental and socio-economic conditions of affected regions, such as arid and semi-arid areas.

The use of biopesticides prevents soil pollution and contamination by various chemicals such as fluoroacetamide. Such natural products are being developed in many countries around the world, avoiding the harmful effects associated with synthetic pesticides. They are also less likely to cause skin irritation in humans and animals, posing minimal risks to people and the environment, a relatively safer alternative for long-term global food security and environmental sustainability. Organic Lauricide-Bio is an organic product extracted from oleander that acts on all soil parasites, particularly gall cyst nematodes and Pratylenchus.

/// Solution for a Resilient Future ///

Compared to traditional pesticides, biopesticides and special nematocides generally have lower intrinsic toxicity. Conventional pesticides, which can impact a variety of organisms, including insects and mammals, biopesticides often only affect the target pest and closely related organisms. Biopesticides are potential alternative products to synthetics pesticides and can be classified as:

- Microbial pesticides consisting of bacteria, fungi, viruses, and sometimes nematodes.
- Bio-derived chemicals that are various substances naturally occurring that control pest populations such as neem oil and other aromatic compounds.
- Plant-incorporated protectants or Genetically Modified (GM) crops.
- RNAi (RNA interference) pesticides. Some of them are applied topically on plants and are absorbed by them.
- Biopesticides can be obtained from byproducts of fermentation, for example, spinosad obtained from sugarcane fermentation.
- Some substances derived from plant extracts such as canola and garlic also have shown pesticidal properties

Biopesticides work primarily in minimal doses and mainly avoiding the pollution issues caused by chemical pesticides. They can significantly reduce the use of chemical pesticides while maintaining excellent crop yields when used as a part of Integrated Pest Management (IPM) programs. However, users must be highly knowledgeable about managing pests and strictly adhere to all label instructions to use biopesticides efficiently (and safely).

"Lauricides" bioproducts are used in biological agriculture and results showed its effect on nematodes even on pests of soils. Producers assert that it is less harmful to the environment than synthetic pesticides and has little impact on other living things.

In terms of application and instructions, Lauricides-bio may be applied during all the year, especially in sandy soils. The estimated amount of product applied per hectare is 10 litres, which costs around €7 per litre. The application of the product has shown that successfully reduces nematode by 97%. There are no specifications in terms of plant species, being applicable to any culture. Lauricides-bio has been sucessfully tested on tomato, garlic and eggplant cultures that were attacked by gall cyst nematodes and Pratylenchus, with also a sucess rate of 97% in reducing the attacks.

The product is registered on copyright, in 167 countries worldwide. It has been awarded with international distictions as having obtained the gold medal award at the International Competition of Inventors, in 2015, and having been honored at the O'naturel Luxembourg event.



Eggplant culture attacked by nematodes, before Lauricie-Bio application.
Author: Walid Saanouni | © Walid Saanouni



Same eggplate culture a few days after Lauricide-Bio application.
Author: Walid Saanouni | © Walid Saanouni

/// Always Moving Forward ///

Agricultural adaptation strategies and actions, with a focus on local and regional levels, include crop varieties and management, including land-use change and innovative agricultural techniques, water and soil management, including agronomic practices, and farmer training and knowledge transfer.

Biopesticides can increase the world's food supply and make agriculture greener, safer and more efficient. One promising approach is the research, development and usage of 'biopesticides', products with lower toxicity that break down easily in the environment. Many companies are working to bring a new range of biopesticides to the market, using innovative technology to create insecticides and fungicides that reduce at most the negative impacts on human health and on the environment. This approach is demanding on research programs and technological investment.

Organic Lauricide-Bio is an organic product extracted from oleander that acts on all soil parasites, particularly gall cyst nematodes and Pratylenchus. A large number of greenhouse growers in Tunisia, Algeria and Morocco have experience with these biopesticides and have shown that this product can be used in their Integrated Pest Management (IPM) programmes in addition to naturally occurring enemies that are commercially available in horticulture. Growers can benefit from several advantages offered by lauricides, including reduced risk to workers and compatibility with biocontrol programmes. Lauricide-Bio has so far been accepted as a product patent, but is in the process of being accepted in international regulations.

Further information

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Mechanical control and management of *Coraebus* in on cork oaks

Coroebus florentinus is a xylophagous beetle that is harmful for trees and the forest environment. Physical or mechanical methods of control will be the most rational strategy to fight those pests without pesticide in Gallura.



Adult insect of the *Coraebus florentinus* species.
Author: Unknown | © Agency Forestas



Branch damage observed on a cork oak tree by *Coraebus florentinus*.
Author: B. De Vaddis | © Agency Forestas

/// Context ///

In the oak forests of Sardinia, the infestations by the buprestid beetles *Coraebus florentinus* and *Coraebus undatus* reached have become widespread, causing both economic losses due to a reduction in quantity and quality of cork and worrying effects on the health status of the plants. These insects behave differently on trees: while the C. florentinus digs tunnels into the upper branches of oaks causing portions of the crown to dry out and facilitating the transmission of pathogenic fungi, the C. undatus depletes cork as its larvae dig subcortical tunnels, which are partly embedded in the cork.

In Italy, due to the recent outbreaks of C. undatus, a national law has been adopted, which stipulates that the extracted cork must be subjected to a heat treatment by boiling before being transported outside the region of extraction. But this is expensive and not even effective on *Coraebus florentinus*, which affects young branches and weakens the entire tree year after year. Currently, the only known effective control practice for containing *Coraebus florentinus* attacks is the manual removal and destruction by fire of the attacked plant parts. This recent phenomenon adds to the numerous causes of the decline of cork oaks including: repeated passage of fires, excessive grazing, poorly executed debarking, deep and frequent plowing, voluntary or accidental elimination of tree recruits renewal, attacks by defoliators insects, drought and climate change.

/// Solution for a Resilient Future ///

The control of *Coraebus florentinus* and *Coraebus undatus* in cork oak forests is carried out in a differentiated manner, taking into account different action plans, which have been defined taking into account the following aspects:

- The larvae of *Coraebus undatus* feed on the layer of meristematic cells that form the cork, severely affecting the quality of the cork and reducing the monetary value of the boards. The galleries are observable only after the removal of the bark.
- The larvae of *Coraebus florentinus* dig subcortical and medullary tunnels in the apical branches of plants. The egg is usually laid at the apex of a shoot or in an acorn and the larvae gradually penetrate the increasingly larger branches (in young plants up to the main stem), covering and destroying even a linear meter of tissue. The maturing larva, before pupating inside the wood, digs a circular subcortical tunnel which interrupts the lymphatic flow and causes the infested branches to dry out.
- In young plants the damage can affect a large part of the foliage or even the entire plant, while in mature plants the damage consists of a more or less extensive reduction of the foliage.

While the control of the *Coraebus undatus* is possible exclusively following cork extraction and is limited to the containment of its spread between regions by boiling the cork before its handling, the control method to reduce *Coraebus florentinus* infestations is carried out by the mechanical removal of the branches that show the symptoms of the attack. This approach does not involve the use of chemical products or antagonistic insects and bacteria, since it simply consists of cutting down affected branches, removing materials from the infestation area and burning them. The activities must be completed at the
end of May, before the beetle adults emerge from the infested branches.

The manual pest control method is always expensive and difficult, if not impossible, to implement on a large scale.

In addition, considering that the cutting of branches must often be carried out at a height of more than two meters, it requires not only the use of normal cutting equipment, but also elevating platforms and safety devices. Operators also need to have the specific skills both to carry out work at height and to recognize the infested plants of the portions of the branch to be cut and the proper handling of the cut material.

The training also covers aspects relating to the possibility of the operators themselves becoming vectors for possible diseases, through the use of tools that have not been properly sterilised, or simply by moving from one area to another. The timing of the intervention is crucial for the containment of the infestation, and the cuts must obviously be made during the period of the life cycle of the insect when it is in the larval state inside the branches. Typically, in the Sardinian climate, this happens in late spring. A wrong timing can totally compromise the success of the intervention.



Mechanical removal of cork oak branches that show the symptoms of the attack., Loc. Loelle Buddusò (SS).
Author: B. de Vaddis | © Agency Forestas



Cork oak tree showing multiple branch dieback symptoms (a), adult and larvae of *Coraebus florentinus* (b,c), and necrotic wood tissues surrounding the beetle gallery (red arrow) on a cork oak branch (d), (From Pinna et al. 2019).
Author: C. Pinna | © MDPI Open Access

/// Always Moving Forward ///

All manual control methods are costly. It is therefore necessary to concentrate resources on the areas where most intervention are need, and to establish monitoring practices to be carried out with appropriate technologies. The following steps are recomended:

1. Definition of a monitoring protocol.
2. Monitoring the presence of the beetle with particular attention to regional cork-growing areas and creation of thematic maps.
3. Training activities for field operators on monitoring and mechanical fighting methods.

Future monitoring and research activities are needed to improve control methods. These should focus on:

- Defining and monitoring the distribution of C. undatus in the subericultural areas of Sardinia by observing the presence of larval galleries in the cork oaks subjected to extraction.
- Studies the phenology of the insects to determine the period of the year when the different developmental stages are present.
- Determination of the period of presence of the live stages in the cork, using emergency cages to catch the adults that emerge from the trunks of the cork trees.
- Research on the influence of silvicultural management practices on the level of C. undatus infestation.
- Testing the influence of mass trapping of females in reducing insect infestation by comparing the effectiveness of different trap models.

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Bat-tling for biodiversity: harnessing nature's pest control with trees

Agroforestry's bat-tastic benefits: Enhancing biodiversity and pest management in Mediterranean landscapes.



Bechstein's bat is a species found in Europe and western Asia, living in extensive areas of woodland. It is classified by IUCNas 'Near Threatened'.
Author: Credits: batslife.eu | © Educational use, non-commercial.



Autonomous Recordings Units (ARUs) are used to record bird and bat populations.
Author: Zack Miller | © Educational use, non-commercial.

/// Context ///

Agroforestry offers a promising approach to enhancing biodiversity and implementing effective Integrated Pest Management (IPM) practices. By increasing habitat heterogeneity, agroforestry systems can maintain diverse and resilient communities of natural enemies that help suppress crop pests.

From the Montado in Portugal – all way to the Cyprus – the key benefit of agroforestry for IPM is the provision of alternative food sources and refugia for beneficial organisms like predators and parasitoids. Trees and shrubs harbour a variety of arthropods that feed on crop pests, which can then move into adjacent crops, providing biological control services and reducing the need for pesticides.

Preliminary scientific evidence highlights how natural landscape features serve as important commuting corridors for bats, enabling them to travel between their roosting sites and foraging areas. Woodland edges, hedgerows or alley cropping systems provide much-needed cover and protection from predators, and three-dimensional structures for echolocation calls to bounce off, acting as important navigational landmarks. However, threats such as habitat loss and fragmentation, the excessive or unnecessary use of agrochemicals, and climate change are accelerating the decline of insect species – a critical component of bats' diets. As we anticipate a northward migration of agricultural pests, it becomes increasingly crucial to preserve the existing pest control services provided by insectivorous bats.

This factsheet is primarily addressed to policymakers, underlining the numerous benefits of natural pest control – while underscoring the urgent need for expanding bat-friendly landscape features across the Mediterranean and beyond. Secondly, farmers, foresters and land managers are responsible for making use of the opportunities and knowledge available in the area of biodiversity-friendly land management – ensuring that species such as bats thrive across Mediterranean landscapes.

Drawing inspiration from the six indicators of sustainable development listed in the EU Taxonomy Regulation, as illustrated in the 'Brno Agroforestry Declaration', we highlight how bats are essential in reducing pest pressure, while also helping farmers save money in the longer run.

/// Solution for a Resilient Future ///

Bats' role in pest control is largely observed. Habitat-rich agroforestry systems play a key role in providing support to bat populations, while in turn, bats play a role in:

- Climate Change Mitigation
  Investing in the protection and restoration of bat habitats can yield significant returns, both in terms of sustainable crop production and broader environmental stewardship. Maintaining diverse, structurally-rich agroforestry habitats that support bat communities affected by e.g. habitat fragmentation may also deliver long-term benefits for climate change mitigation.
- Climate Change Adaptation
  In the Mediterranean region, preserving and enhancing bat populations should become a key strategy for building resilience in the face of future agro-environmental challenges. As climate change and other threats continue to impact agricultural systems, the pest control provided by bats will become increasingly important for ensuring food security and ecosystem stability.
- Protection of Biodiversity and Ecosystems
- Research has shown that bats can act as effective suppressors of insect pests in agroforestry settings, providing valuable pest control services that benefit crop production. By consuming a variety of insects – including carriers of agricultural pathogens or insect pests, bats play a vital role in maintaining the health and productivity of farming systems.
- Literature review (Tuneu-Corral, 2023) flagged that only 11 out of the 66 studies on 'pest suppression by bats' were conducted in Europe. Recognising and quantifying the

economic value of bats' pest control role is crucial for informing agricultural practices and land management policies that support the conservation of these beneficial animals.

- Rural socio-economics
  The above-mentioned review examined the economic value of the ecosystem services provided by bats as agricultural pest suppressors. Even the most conservative estimates are astonishing. In temperate climates, bats could save corn growers $7.88 per hectare per year in pest control costs. Extrapolated to the total global land area under corn cultivation, this equates to over $1 billion in potential savings. The review also found that bats' pest control services are worth an estimated $188 to $248 per hectare per year in Chilean vineyards (Rodríguez-San Pedro et al., 2020). If applied to the total vineyard area across the European Union, this would translate to around 700 million EUR in value.
- These figures underscore the immense economic benefits that bats provide to agriculture through their natural pest suppression abilities. By consuming vast quantities of insects, including many crop pests, bats deliver a valuable ecosystem service that can significantly reduce the need for costly and environmentally harmful pesticides.
- Skills, Policies and Generation Renewal
  In light of the discussion on the EU Long-Term Vision for Rural Areas, it becomes clear that the future generation of farmers and foresters should gain the right skills to contribute to preserving bat populations affected by the expansion of agriculture or habitat fragmentation. These land managers have the potential to engage in new activities on ecosystem stewardship, making their profession more attractive for adolescents and young adults.



Corn grown between rows of hybrid poplar and black walnut (in background) at the University of Guelph Research station.
Author: Maren Oelbermann | © Educational use, non-commercial.



Vineyard agroforestry, also known as 'vitiforestry', is a system that allows bat populations to thrive.
Author: Bonterra Vineyards | © Educational use, non-commercial.

/// Always Moving Forward ///

While agroforestry systems in the Mediterranean provide valuable habitat for bats and other biodiversity, more work is needed to fully realise the potential of these integrated landscapes to support thriving bat populations and the ecosystem services they provide. This includes:

- Developing decision support tools and guidelines to ensure that agroforestry systems are designed and managed to maximise their value for bats. This includes maintaining a diversity of tree and shrub species and minimising the use of pesticides that could harm bats or their insect prey. Developing best management practices for bat conservation in Mediterranean agroforestry systems can help guide farmers and land managers in this effort.
- Establishing certification schemes and traceability to market agroforestry products derived from 'bat-friendly' areas/regions.
- Providing financial incentives and support for landowners and communities to expand the area under agroforestry management in the Mediterranean region.
- Promoting research and innovation to better monitor and understand the long-term impacts of agroforestry on bat populations and the ecosystem services they provide.
- Fostering knowledge-sharing and capacity-building by raising awareness about the importance of bats and their role.

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Authors: Constantin Muraru, Gerry Lawson, Daniel Monteleone | **Partners:** EURAF – European Federation of Agroforestry

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Controlling rat population with barn owl artificial nests

Reactivating farmers on abandoned land in Deneia, Cyprus.



Barn owl natural nest.
Author: Unidentified | © Educational use, non-commercial.



Barn owl artificial nest in Deneia, Cyprus.
Author: Unidentified | © Educational use, non-commercial.

/// Context ///

The community of Deneia is located just west of the city of Nicosia, capital of Cyprus, with large portions of its lands situated within and adjacent to the United Nations "Buffer Zone" of the Ceasefire-Line; one of the main reasons for abandonment of Deneia's very large areas of agricultural land by its residents and farmers. When some tried to reactivate their agricultural crops, they faced a huge problem – even beyond that of the occupation of their lands by a third-country army – as in the previous 15 years this community suffered a serious problem related to the uncontrolled population of rodents.

After many attempts and many chemicals, that started to create other problems, the Community authority proceeded to implement a nature-based solution: it "joined forces" with the Barn Owls, and through intensive nesting the results are still impressive to this day, helping many other communities that were facing the same problem to solve it with a tailored-to-need application. The idea of balancing and respecting the food-chain has also inspired the use of other species to deal with other threats in a natural fit-for-purpose way.

Barn owls (*Tyto alba*) are nocturnal birds of prey known for their effectiveness in controlling rodent populations. By providing suitable nesting sites, it is possible to harness their natural predatory behaviour to manage rat populations in agricultural and urban environments. The Barn Owl is found on all continents except Antarctica and occupies a wide range of habitats and altitudes, including deserts, grasslands, forests, agricultural fields and urban areas.

/// Solution for a Resilient Future ///

Studies on Barn Owl diet show that they feed almost exclusively on rodents, with 96% of their diet comprised of rodents like rats, mice and shrews. As a result, a single Barn Owl can catch and eat up to 1000 rodents per year. During the breeding season, Barn Owls mainly hunt within a short 1 km radius around their nest, sometimes ranging up to 4.5 km away.

Benefits of using barn owls for pest control:

1. Natural Predators: Barn owls are skilled hunters that primarily feed on rodents such as mice, rats, voles, and shrews.

2. Effective Hunters: Barn owls have excellent nocturnal vision and acute hearing, allowing them to locate and capture prey with precision.

3. Low Environmental Impact: Unlike chemical pesticides, barn owls pose no harm to the environment, non-target species, or human health.

4. Cost-Effective: Implementing barn owl nest boxes for rodent control can be a cost-effective long-term solution compared to ongoing pesticide use.

Implementing barn owl artificial nests

- Artificial Box Placement: Nest boxes were installed in strategic locations where rats are known to frequent, and cameras were also installed to give further data
- Design and Construction: Nests were designed specifically for the particular bird, its biology and needs, using Marine Plywood that is resistant to weather conditions

- Monitoring and Maintenance: The team regularly monitored the nest for necessary maintenance and avoid nesting of other species. Data were collected from the cameras and valuable results were recorded.

Habitat Management: In collaboration with the Community, the Team decided to minimize walls and barriers made fully of concrete, and to replace them by installing gabions, which favour the free movement, hunting and breeding of wildlife species; hence fostering the occurrence of balance in a natural unhindered cycle.

Education and Outreach: In the Community, many training and information seminars were held for the population, as well as the inclusion of residents, farmers and young people in the efforts to build the nests, install and monitor them. At the same time, the neighbouring communities of Mammari and Kokkinotrimithia participated in the implementation of the project, to which the project was extended to this day, population is so large that it must be expanded. The schools of the area also had a special participation, either with painting or essay competitions for a better understanding of the project, while there were not a few times that other mayors and community leaders of Cyprus visited the community for information and education, proceeding in turn to their own communities the designs and installation of corresponding projects.

Collaboration: The established group had as key members: the Community Authority, a wildlife manager, the Government's Game and Wildlife Service, as well as a representative from the civic society organization of "BirdLife Cyprus".



Artifical nest and barn owl.
Author: Unidentified | © Educational use, non-commercial.



Barn owl chick in the artificial nest.
Author: Unidentified | © Educational use, non-commercial.

/// Always Moving Forward ///

Because of this pilot project and its results, the Community today has been freed from large rodent populations and their consequences, and as a result has eliminated the use of chemicals and pesticides in crops to protect wildlife and its habitats. An estimated 70% of Deneia's farmers are practicing organic farming, and the aim is to reach 100% in the next five years. Based on the above, more people who want to engage in organic farming choose this particular community both for activity and permanent residency. The education, culture and awareness cultivated helps the inhabitants in the whole range of their daily decisions, thus promoting more and more nature-based solutions.

Recently, in January 2023, Deneia Community received an award supported by the Office of the Environment Commissioner of the Republic of Cyprus, regarding the Community's Overall Environmental Activity, hence becoming an example to be followed by many other communities in Cyprus.

Encouraging Barn Owls as a biological rodent control is a method widely used in other countries. In Israel, this method has been successfully used since the 80s, reducing rodenticide use by 80% since 2006. Today, Israel has more than 4,500 nest boxes installed around the country.

Further information

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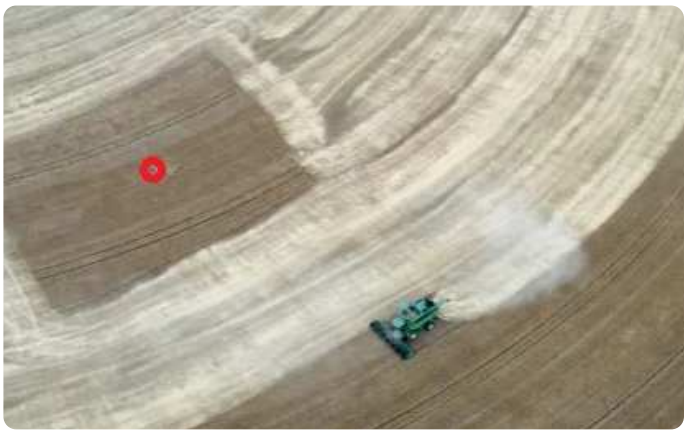
ResAlliance

URPA: A beer that protects the Montagu's harrier nests in Catalonia

A beer brewed with barley that cannot be harvested due to the presence of nests, to help producers market all this production which would otherwise be lost.



Montagu's harrier (*Circus pygargus*).
Author: Limonium Natura. | © Educational use, non-commercial.



Barley field being mown with a protective buffer (half a hectare) around the nest (red circle).
Author: Limonium Natura. | © Educational use, non-commercial.

/// Context ///

In Catalonia, for more than twenty years, the administration has been working for the conservation of the Montagu's harrier (Circus pygargus). It is an endangered migratory bird of prey, typical of open landscapes and which mainly breeds in cereal fields. The early mowing period due to the use of new crop varieties means that many nests can be carved up by the combine harvesters. For this reason in Catalonia it is obligatory to leave half of a hectare of cereal field unmown, where it nests, in exchange for the farmers receiving compensation for the loss of this yield.

In 2022, a group of local naturalists from the Limonium Natura association took the initiative to buy the ripe barley from two fields where the Montagu's harrier had nested and make a special, unique beer. Thanks to this action the product contributes to the economic viability of the good conservation practices for nest conservation. Urpa, the nest-saving beer, was born also with the objective of visualizing the problems of the species and with the idea, in the long run, of helping to finance measures for the protection of the Montagu's harrier and its habitat.

/// Solution for a Resilient Future ///

The Montagu's harrier is a globally vulnerable migratory bird of prey that thrives in open landscapes, primarily breeding in cereal fields. These fields are the modern equivalents of the natural grasslands and scrublands where the harrier originally nested. Across Europe, the species is facing severe declines due to agricultural intensification. In Spain alone, 25% of Montagu's harrier pairs have been lost in the last decade. One significant factor is the use of new cereal varieties, which allow for an earlier mowing period. This early mowing leads to many nests being destroyed by combine harvesters. Additionally, the use of pesticides and the loss of field borders and fallow land further threaten the Montagu's harrier and many other birds in dryland agricultural landscapes.

To reduce nest destruction and improve the situation of the Montagu's Harrier in Catalonia, which was on the brink of extinction in 1980, administrative technicians, rural agents and other specialists carry out annual surveys of potential breeding sites to detect nests and apply protection measures. In parallel, farmers play a crucial role in this process by alerting rural agents when they spot the species in their fields. Once a nest is detected, the administration implements several protection measures: georeferencing, fencing and monitoring throughout the season until the hatchlings leave the nest. They also require half a hectare of cereal or forage crops to be left unmown, and compensate farmers for the loss of this crop. This system works well thanks to the commitment of all parties involved.

However, the compensation often arrives slowly due to bureaucratic processes, and leaving the field unmowed is understandably inconvenient for farmers, even with eventual compensation.

In 2022, after many years of considering the idea, a group of local naturalists from the Limonium Natura association took the initiative to buy ripe barley from two fields where Montagu's harriers had nested to brew a very special, unique beer. The aim of this initiative was to highlight the plight of the species and, in the long term, to help fund conservation measures for the harrier and its habitat. It is expected that in future seasons, if the initiative is successful and there is demand for the beer, more barley will be purchased from conservation buffers.

Currently in Catalonia, the protection actions implemented since the 1990s have allowed the recovery of Montagu's harrier numbers, increasing the total population to about 90-100 pairs in recent years. This represents a higher population than those recorded in 1970.



Protected nest.
Author: Limonium Natura. | © Educational use, non-commercial.



The final product: URPA, the nest saving beer.
Author: Limonium Natura. | © Educational use, non-commercial.

/// Always Moving Forward ///

The documentary "URPA, a cool drink to save the Montagu's harrier (in catalan)" explains the work of the people who have been working for decades in the plains of Lleida to protect this globally threatened bird, closely following its nesting during one season, from April to August. And in parallel, it shows the genuine and innovative proposal to convert the cereal from the fields that are left unmown to protect the harrier's nests, in a craft beer, the Urpa, to reward and give visibility to the peasantry involved.

All the protagonists of this small story of complicity and success have voice, from farmers to scientists, with the desire to spread an inspiring reality with the potential to be replicated in other places. The documentary, like the Urpa initiative itself, aims to contribute to bridging the gap between the agricultural and nature conservation worlds, and to highlight that complicities and synergies can be woven between both worlds, part of one and the same.

Funded primarily through the crowdfunding platform Verkami, through more than 300 donations collected during 2023, this iniciative has reached other localities in Spain with a similar casuistry in terms of nest conservation and positive synergies are being created for its replication in these localities.

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ResAlliance

Building resilient beekeeping production to climate change in the Rodopi mountain range, northern Greece

Return of bee colonies to the mountains: a necessary condition for their survival and the preservation of landscape biodiversity.



Honey bee and pollen.
Author: Sofia Gounari | © Educational use, non-commercial.



Beekeeping in Rodopi mountain range.
Author: Sofia Gounari | © Educational use, non-commercial.

/// Context ///

Over the last 50 years, the abandonment of mountain villages in Greece has also led to the disappearance of beehives from the mountains, a traditional activity of the inhabitants. In addition, the arrival of the Varroa destructor mite, the main enemy of bee colonies, led to the extinction of wild honeybees. Beekeepers have concentrated at low altitudes, using mainly cultivated plants and trees (Citrus sinensis) or scrubland (Erica arborea). Rising temperatures shorten the flowering period of these plants or often prevent them from flowering at all. Bee colonies thus face a severe shortage of nectar and pollen, while production costs increase due to feeding and transport to find new flowers.

Bee colonies in these areas also are exposed to plant insecticides and herbicides, which, they do kill the worker bees and accumulate in the hive and cause chronic poisoning, while their combination with insecticides used by beekeepers increases their toxic effect.

In the face of the decline of natural pollinators (bumblebees, other insects, birds), the honeybee is emerging as the guardian of biodiversity, pollinating 90% of wild plants on the planet and 75% of food crops.

The return of beekeeping to forests, mountainous and hilly areas will have multiple environmental, social and economic benefits. It will provide an economic outlet for the inhabitants of mountain villages, who will protect and enhance it through active management of its natural resources.

/// Solution for a Resilient Future ///

Climate change threatens the well-being of bees and forests. Practicing beekeeping in the forest can help both beehives and the forest to cope with the effects of climate change.

The forest needs honey bees and beekeeping:

- Conservation of flora and fauna biodiversity. 86% of forest species are pollinated by bees;
- Production of fruits, nuts and seeds that feed mammals, birds, insects and forest animals, each of which contributes to the conservation of the forest.
- Improvement of soil fertility through pollination of mountain meadow plants, e.g. wild clover.

Beekeeping in the forest does not impoverish – it enriches, does not destroy – it protects. Honeybees and beekeeping need the forest for:

Synchronisation of the bee's biological cycle with the flowering season.

- Reduction of the need for food during hibernation, reduction of production costs.
- More efficient use of flowering plants, less overcrowding.
- Reduced Varroa mite infestation of hives due to interruption of egg laying during hibernation, reduced production costs.
- Protection against poisons.
- Summer flowering, when it is completed in the lowlands.

70-80% of the annual honey production in Greece is produced in forested, mountainous or semi-mountainous areas. The return of bee colonies to mountainous areas, apart from being a way out for the survival of the beekeeping sector, the reduction of production costs and the production of quality products with high biological value, will also strengthen life in abandoned mountain villages. It will provide an economic outlet for young people, while agro-tourism activities will sensitise urban visitors to the importance of the forest and food production.

In northern Greece, in the Rodopi mountain range national park, two apiaries have been created at an altitude of 1.500 m, protected by electric fences. The beehives are placed on specially shaped scales with sensors that measure in real time the weight of the hive, the temperature and the humidity.



Meadow in Greece.
Author: Sofia Gounari | © Educational use, non-commercial.



Beekeper's training in new management techniques.
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/// Always Moving Forward ///

Together with the sector's inherent vulnerability to climatic conditions, it is necessary to strengthen the capacity of producers to effectively collect and use the necessary information on their production and to adapt their farming practices in time, in the context of so-called 'precision farming'.

Similarly, precision beekeeping is a system of beekeeping based on information and technology. Technology is used to collect, evaluate and combine data on the biology of the organism – the colony – beekeeping techniques and climatic data in order to create models that can help the beekeeper to increase production, reduce production costs and at the same time protect and optimise the quality characteristics of the products produced.

The peculiarity of beekeeping, in comparison with other agricultural activities, is that the production of apiculture products, honey, pollen, royal jelly, etc., is the result of a natural system whose elements are the plant, the bee and the beekeeper, and whose main regulator is the climatic conditions. To be able to make models in this case, it is necessary to study the relationship of each element to the production separately and then to study their criticality in the final result.

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The potential of the Honeydew honey from Montesinho Natural Park oak forest as a non-wood forest product

A superior quality product and its relationship with the floral richness of the Montesinho Natural Park in Bragança, Portugal.



Honey bee collecting honeydew.
Author: M. Carmen Seijo Coello | © Educational use, non-commercial.



Main landscape of the Montesinho Natural Park oak forest.
Author: M Shantal Rodríguez Flores | © Educational use, non-commercial.

/// Context ///

In recent years, the lack of competitiveness of the forestry sector and the desertification of rural areas have had a significant socio-economic impact on the areas surrounding the Montesinho natural park (MNP). One potential solution is the implementation of strategies that facilitate the economic recovery of these areas through the promotion of sustainable activities such as beekeeping. Honey production has the potential to provide a source of income, stimulate the local economy, and support the social and environmental sustainability of the MNP.

The ACORNDEW project has been designed with the objective of facilitating sustainable forest management and the development of novel and differentiated regional products derived from the MNP oak forest and neighboring regions. One of the main objectives was to boost the sustainability of the Quercus pyrenaica oak forest of the MNP through the implementation of innovative approaches.

Within the general scope, this project aimed to examine the honeydew honey produced by the Q. pyrenaica tree. Data on the production of this honeydew honey have been collected over three seasons, and the honeydew honey has been subjected to melissopalynological and physicochemical characterization. This characterization serves as a tool for authenticating the botanical origin of the honeydew.

/// Solution for a Resilient Future ///

Honey bees are capable of procuring honey from plant secretions that are not nectar, including honeydew. The resulting honey is designated as honeydew honey. Honeydew honey is among the most highly sought-after honey in the beekeeping market and is particularly well-regarded by consumers in the EU. It is particularly associated with its high content of bioactive compounds and high antioxidant capacity, which render it an intriguing candidate for human health applications.

In the Montesinho Oak Forest Natural Park, the production of honeydew is mainly due to the extrafloral secretion of the acorns of Q. pyrenaica and its hybrids. The secretion is characterized by high viscosity and can form bubbles that accumulate at the edges of the acorn dome, where honey bees collect significant quantities of this raw material. It is produced in the summer when the fruits begin to form, specifically from mid-July to August. This period corresponds with the accumulation of pollen and nectar from plants such as the chestnut, the blackberry, the heather, and the broom, plant species with a great interest to honey bees in terms of foraging. Therefore, the pollens of these plants were present in a significant proportion in this honey type from this region. Pollens from some forest clearing plants such as herbs, sub-shrubs and shrubs were also present. Thus, thyme, plantain, mignonette, fennel, clover, viper's bugloss, and flax-leaved daphne were present at high frequencies and functioned as secondary and important pollens. Other common pollens were dandelion, grasses, cornflower, and rockrose. All these pollens are common in the honey produced in this region. In terms of pollen richness, the honeydew honey has a medium pollen content and is classified in Maurizio's classes II and III. In comparison to other honeydew honeys, this honey exhibited a relatively lower average value. Consequently, the honeydew index (HDE/P) value was found to be below 1, a figure that is lower than that observed in other honeydew honeys.

Honeydew honey is distinguished by a dark-to-dark amber colour and a characteristic vegetal aroma. The flavour profile is sweet, with the potential for detection of salty and/or bitter notes. The volatile profile revealed that the highest relative concentrations were observed for 1-nonanol

and linalool oxide. This particular honeydew honey was found to comply with the established quality standards for honey. This type of honey exhibited elevated electrical conductivity and pH. The sugar profile was distinguished by a relatively low concentration of reducing sugars, a low presence of trehalose, and the presence of sucrose, maltose, melezitose, and erlose. Regarding the mineral content, these honeys exhibited a high concentration of minerals, with potassium being the most abundant element. The presence of magnesium was highlighted, followed by calcium and phosphorus. The honeydew honeys studied exhibited a high content of phenolic substances. These properties contributed to the high antioxidant activity observed in these honeys.



Apiary located in MNP.
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Some of the honeydew honey samples analysed in the Acorndew project.
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/// Always Moving Forward ///

The project has enabled the differentiation and characterization of a regional product, such as honeydew honey, from the MNP oak forest. However, climatic conditions exert an influence on the secretion of honeydew, with some years exhibiting greater production than others. As a result, the year of harvest exerts a significant influence on the production of the honeydew honey. The climatic characteristics of certain years also determine the botanical origin. Therefore, it is necessary to study a greater number of harvests to obtain greater precision in the characterization of this type of honey.

The identification of biomarkers is of paramount importance for the classification and authentication of unifloral honey. Despite the growing number of studies on this topic, there is still a need to address this issue for honeys such as honeydew honey. Therefore, it is crucial to integrate new techniques for characterizing this type of honey, enabling its differentiation through specific biomarkers. This will enhance the value of the product on the market while simultaneously protecting the habitats from which it originates.

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ACORNDEW
BOOSTING THE SUSTAINABILITY OF THE MONTESINHO NATURAL PARK OAK FOREST THROUGH INNOVATION: VALORIZATION OF ACORN AND HONEYDEW

Authors: María Shantal Rodríguez-Flores, Soraia Isabel Domingues Marcos Falcão

Partners: ISA – Instituto Superior De Agronomia

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Pyrenean oak acorn: a non-wood forest product from the forests of northern Portugal

Understanding the potential of acorn availability and the main drivers for the Montesinho Natural Park, Portugal, is crucial for the creation of new value chains.



Figure 1. Different categories of acorn development.
Author: Tiago Lima (ISA) | © Educational use, non-commercial.



Figura 2. Pyrenean oak stand in the Montesinho Natural Park.
Author: Tiago Lima (ISA) | © Educational use, non-commercial.

/// Context ///

The low productivity of agricultural land in the northern region of Portugal has led to land abandonment and the migration of the population. With depopulation comes the problem of the landscape resilience, which can be mitigated by developing sustainable agriculture and forestry value chains that will enable the socio-economic valorisation of the regions, creating jobs and retaining the population.

The region has large areas of Pyrenean oak (Quercus pyrenaica), but the value chain of the species acorn is considerably underexploited when compared to other oaks present in the Portuguese forest. This non-wood forest product collected from other oak species such as the holm oak is used for the production of acorn flour and a diversity of gluten-free products suitable for coeliacs. Knowing the availability of acorns in the region is determinant for the development of local initiatives.

The results of the inventory of acorn availability in this region allowed to estimate the abundance of acorns that have reached the last stage of maturity. The values are reported in dry weight, including the acorn shell and excluding the acorn domes. In 2022, the mean acorn abundance was estimated to be 109.4 kg/ha (95% Confidence Interval (CI):]52.9 ; 165.9[ ) and in 2023, 84.9 kg/ha (95% CI:]52.8 ; 117. 1[ ). With regard to the acorn domes, in 2022 a mean of 26.3 kg/ha was estimated (95% CI:]17.2 ; 35.4[ ) and in 2023 of 13.2 kg/ha (95% CI:]7.8 ; 18.6[ ).

/// Solution for a Resilient Future ///

An inventory of acorn availability was carried out in the Montesinho Natural Park on 59 plots in 4 different areas in order to estimate the availability of acorns and their products over a 2-year period. This inventory considered the following breakdown: acorns harvested before reaching the final stage of maturity (category f + g) and acorns that had reached the final stage of maturity (category h) (Figure 1). The domes of the acorns that had reached the final stage of maturity were counted separately. The acorns were dried in an oven at 60 °C for 7 days with forced ventilation, then counted and their weight (g) determined.

The mean proportion of category h acorns was quantified in relation to the total number of acorns, as well as f and g acorns, with the first year having more fully developed acorns. The mean individual h acorn weight was also considerably higher in 2022. These results indicate that a smaller amount of category h acorns results in larger acorns (Table 1).

The assessment of acorn availability showed a high overall production in 2022, but that in average pyrenean oak forests produce between 84.9 and 109.4 kg/ha of acorn available for consumption (Figure 3). Additionally, these stands also produce in average between 62.1 to 65.9 kg/ha of f+g category acorns and 13.22 to 26.30 kg/ha of acorn domes (Figure 4, Table 1).

	% h Acorns		% f and g Acorns	
	Mean	CI	Mean	CI
2022	17.78	]14.1 ; 21.4[	82.22	]85.9 ; 78.6[
2023	2.46	]1.7 ; 3.3[	97.54	]98.3 ; 96.7[
	Quantity of h Acorns (kg/ha)		Quantity of f and g Acorns (kg/ha)	
	Mean	CI	Mean	CI
2022	109.4	]52.9 ; 165.9[	65.89	]53.2 ; 78.6[
2023	84.9	]52.8 ; 117.1[	62.1	]37.4 ; 86.9[
	Individual weight of h Acorns		Weight of Acorn Domes (kg/ha)	
	Mean	CI	Mean	CI
2022	1.17	]1.0 ; 1.4[	26.30	]17.2 ; 35.4[
2023	4.35	]2.5 ; 6.2[	13.22	]7.8 ; 18.6[

Understanding the potential of production of these forest is important for defining the strategy for the different stages of the oak products.

Table 1. Estimated production and weighted values of Pyrenean oak in the Montesinho Natural Park. CI means the 95% Confidence Interval.

The models for estimating the availability of acorns in the different categories considered are presented by Rios (2024). From an analysis of the models developed and their parameters, it can be concluded that the availability of acorns of category h is reduced in stands with a higher number of trees per hectare. The same is true when the variable is expressed in terms of the number of acorns. On the other hand, it can be seen that the greater the mean square diameter of the stand, the greater the weight and number of category h acorns available.

Considering the amount of acorns that do not reach the final development stage and the amount of acorn domes available, it is important to consider these materials for their potential under a circular bio economy context. Acorns are rich in various compounds such as ash content, total extractives, total lignin, sugars and phenolic compounds (flavonoids and **condensed** tannins) with antioxidant capacity, which can be exploited for food, nutraceuticals and cosmetics (Caeiro, 2024).

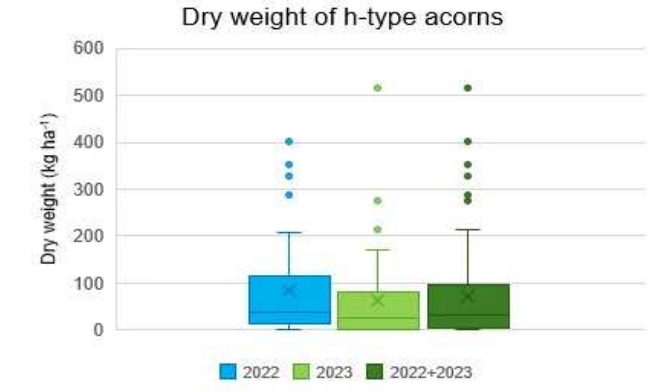


Figure 3. Dry weight of h-type acorns (kg/ha) in the years 2022, 2023 and combined 2022+2023. One outlier from 2022 is not shown to improve readability. The outlier has a value of 1420 (kg/ha).
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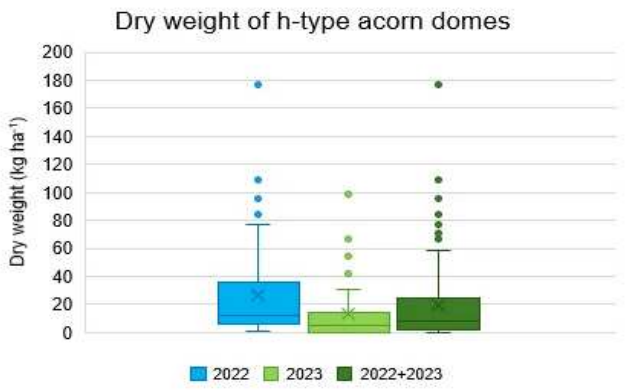


Figure 4. Dry weight of type h acorn domes (kg/ha) in 2022, 2023 and the sum of both years (2022 and 2023).
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/// Always Moving Forward ///

Wild animals feeding and domestic grazing on acorns can slightly alter the values presented above. Estimates of acorn availability can be improved and made more robust by continuing the acorn inventory for several years in a row. Linking acorn availability values with meteorological data, forest stands and soil characteristics, could provide relevant information on acorn availability as a function of the above variables, and contribute to new silvicultural approaches for multipurpose management of Pyrenean oak stands.

Acorn harvesting is essentially manual, which makes the process time consuming and costly, and there is a shortage of labour in the interior regions. Mechanical harvesting technology is underdeveloped, although some attempts have been made to adapt equipment used for other crops such as olives and chestnuts. In the future, equipment and technology may be developed or harvesting methods improved to speed up the process and make harvesting more economical.

By investing in research and continuing to collect data, it will be possible to improve the estimates of acorn prediction models, as well as improving forestry models in terms of acorn availability.

The acorn value chain needs to be improved through the development of food products and the associated marketing of products containing acorns.

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ACORNDEW
BOOSTING THE SUSTAINABILITY OF THE MONTESINHO NATURAL PARK OAK FOREST THROUGH INNOVATION: VALORIZATION OF ACORN AND HONEYDEW

Authors: Diana Isa Santos, Paulo Firmino, Margarida Rios and Joana Amaral Paulo

Partners: ISA – Instituto Superior De Agronomia

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The potential of the Pyrenean oak acorn as a source of gluten-free flour

Impact of different tannin removal processes on the Pyrenean acorn flour characteristics.



Quercus Pyrenean.
Author: Soraia Falcão | © Educational use, non-commercial.



Acorn flour.
Author: Volkan Aylanc | © Educational use, non-commercial.

/// Context ///

The acorn is a wild fruit widely distributed throughout the world and commonly used as animal feed. The Pyrenean oak (*Quercus pyrenaica*) is one of the main components of the Portuguese forest. It is one source of acorns, which can be used for the development of several human food products, depending on the characteristics of the acorn flour obtained.

An important aspect related to acorns is the amount of tannins present, that can imply an astringent flavor, making it difficult to digest and absorb nutrients. Different types of treatments were tested in the acorns (three with tannin removal treatments and one without removal): untreated, blanched, soaked and roasted. After each treatment they were processed into flour and assessed for different nutritional parameters such as moisture, ash, protein content, total lipid content, fiber, starch, fatty acids, sugars and phenolic compounds.

The results showed that the flour obtained by roasting had a lower water content, a high content of fiber, proteins and fatty acids. However, the flour with the treatment of scalding was the most advantageous for human consumption due to its lower content of phenolic compounds. In conclusion, the rich nutritional profile of Q. pyrenaica acorn flour, combined with the fact that it is a gluten-free product, opens up good opportunities for the application of acorn flour in innovative products in the food industry.

/// Solution for a Resilient Future ///

Acorns, characterized by their astringent flavor due to a high tannin content, were utilized in powdered form for consumption as an alternative to conventional flours. In the case of these fruits, which were roasted and cooked, various processing methods such as heating, leaching, or intricate detoxification techniques involving the use of clay were employed to eliminate tannins. On the other hand, sweet acorns were directly consumed without undergoing tannin removal processes.

According to the literature, acorn flour is obtained from the embryo, discarding the pericarp and dome. The embryo is subjected to a drying and crushing process to remove moisture, thus offering greater stability to the product. However, acorns have a high tannin content, which in addition to introducing an astringent flavor to the flour, also has anti-nutritional properties, making digestion difficult and may cause damage to the intestinal epithelium, liver and kidney tissues. That being said, the removal of these compounds from the flour is essential to obtain acorn flour rich in minerals, and fiber. For the removal of these compounds, the acorns were previously peeled and separated into 4 groups, 3 of which underwent tannin removal processes, and the remaining group received no treatment.

The acorn samples were collected in their mature state, and the location of their harvest was in Portugal, in Aldeia Prada, Vinhais (Montesinho Natural Park) in October 2021. These were frozen at -20 ºC until the day of use. The pericarp and dome were removed, after which they were separated into four groups. One group was left untreated and the remaining was divided into three groups and were subjected to different types of treatment processes, namely soaked, scalding, and roasting to be evaluated at a later nutritional level

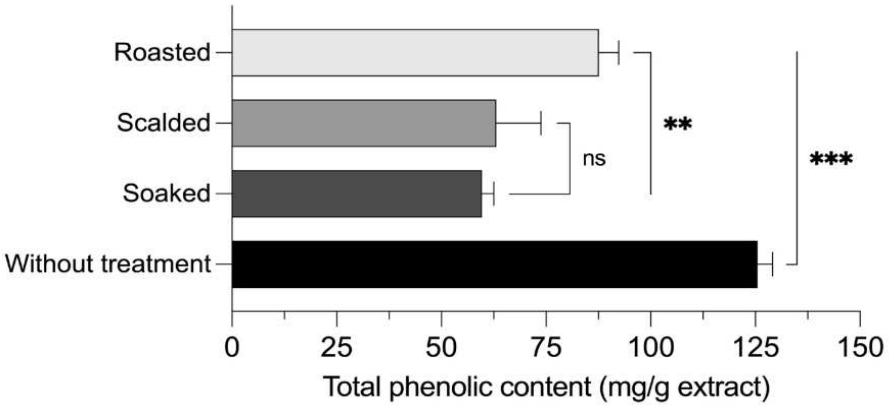
In the immersion treatment, the acorns were placed in water at room temperature for 20 hours. In the scalding treatment, the acorns were immersed in boiling water at 100 ºC for 1 hour. For roasting treatment, the acorns were submitted to an oven (Becken, Worten Equipamentos, Portugal) preheated to 200 ºC for 15 minutes. Subsequently, the acorn samples, excluding those with roasting treatment and including those without treatment, were dried collectively in

an oven (Memmert UNE400, Schwabach, Germany) at 40 ºC for 3 days. After drying, all samples, including the roasted ones, were submitted to grinding for 1 minute at speed 10 using a laboratory mixer (Bimby, Thermomix Company, Germany) and subsequently stored at room temperature for further analysis.

The tannins (within the phenolic compounds) for untreated acorn flour samples, as expected, obtained a higher content of phenolic compounds (125.5 ± 3.6 mg/g), while the scalded acorn flour samples had the lowest content of phenolic compounds with the value of 63.1 ± 10.7 mg/g.



Acorn Quercus Pyrenean.
Author: Soraia Falcão | © Educational use, non-commercial.



Total phenolic content.
Author: GraphPad Prism versão 9.3 | © Educational use, non-commercial.

/// Always Moving Forward ///

About 1% of the world's population with gluten intake have an autoimmune celiac disease. Utilizing these fruits for human consumption proves advantageous from both an economic and sustainable standpoint. Also, given the prevailing trend of population escalation, diversification of food sources is important to avert resource scarcity. The acorn, a valuable by-product of forests, remains underappreciated despite its potential significance. Other food products are being developed from the acorn flour such as gluten-free pancakes.

Acorn oil was also extracted and characterized, but the process of extraction has proven to be difficult reaching low yields. Due to the rich nutritional composition shown by the acorn oil, the process for obtaining it was optimized. Different methodologies were tested such as cold-pressing and solvent extraction. Although cold-pressing methodology is described to retain more the oil´s raw properties, the yield obtained was very low. For solvent extraction, two methodologies were tested, soxhlet and ultra-sound extraction. A higher yield, approximately of 5%, was obtained with the soxhlet extraction. After the extraction the composition in fatty acids and vitamin E were evaluated with the oil obtained through the soxhlet extraction presenting a higher content of these compounds.

The low yield obtained is one of the several challenges related to acorn oil production, because acorns, generally contain low amounts of oil compared to other nuts, turning the extraction less efficient and less economically viable. Although solvent extraction presented a higher yield when comparing to the cold-pressing methods, it may not be desirable for producers aiming for natural, organic, or health-focused markets, where cold-pressed oils are preferred. For future work, new methods to extract oil should be tested, such as apply a roasting treatment before the extraction or use expeller pressing methodologies.

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ACORNDEW
BOOSTING THE SUSTAINABILITY OF THE MONTESINHO NATURAL PARK OAK FOREST THROUGH INNOVATION: VALORIZATION OF ACORN AND HONEYDEW

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Good practice(s): Management alternatives, Financing

Aleppo pine cones and seeds: A non-wood forest products from the natural forests of Tunisia

Predicting cone and seed availability and understanding critical key production drivers to strengthening value chains.



Mature Aleppo pine cones in Beja Forest (North-Western), in Tunisia.
Author: Abdelaziz Ayari | © Abdelaziz Ayari



Aleppo pine tree in Beja forest (North western), in Tunisia.
Author: Abdelaziz Ayari | © Abdelaziz Ayari

/// Context ///

The Aleppo pine (Pinus halepensis Mill.) is a Mediterranean coniferous species with large geographical distribution from Morocco and Spain in the Western Mediterranean Basin to Lebanon, Syria and Jordan in the Eastern part. In North Africa, it's also the most widely spread pine, well represented, especially in Algeria, Tunisia and Morocco covering about 1.3 million hectares.

Natural Aleppo pine forests grow in North Africa at elevations ranging from about 250 m above sea level in Algeria, Morocco and Tunisia to 2000 m in Morocco. It has been also observed in different bioclimatic zones, from the sub-humid to the arid climates. During the 19th century, Pinus halepensis was also introduced to the United States of America, Australia, Venezuela and South Africa.

A Tunisian social demand of Aleppo pine's seeds has been increased in the last three decades ago starting from 1990s, due to the increasing seed use in the preparation of a various cream, especially on the celebration period of the prophet Mohamed, and as a result, the most productive pine forest have been harvested. To celebrate it, an annual cone weight of about 300 tons of seeds is collected. The annual seeds price was varying from 7 to 10 €/Kg in 2023. The high nutritional value of Aleppo pine seeds, 34% crude fat and 25% protein contents, explain their high consumption. However, their seeds are needed to provide food resources to fauna and contribute for the survival of a wide variety of predators to maintain a biotic equilibrium with high biodiversity.

Main worldwide Aleppo pine forest area and yearly needs consumption of Tunisian's population to Aleppo pine seeds.

Tunisian study conducted relating natural forests to bioclimatic areas with representative trees of populations for cones and seeds in terms of weight and number from the wettest to driest zones.

The production of cones and seeds is quite variable, with differences between years, stands and individual trees measurements and remains strongly affected by an impact of various environmental factors. Effect of bioclimatic zones and geographic sites on cone and seed properties and their impact on seed crops. To increase cone and seed crop within Aleppo pine Tunisian forests, it is crucial to implement silvicultural models and decision support tools which helps foresters for selecting better locations for new plantations.

Traits Aleppo pine cones behaviours and models developped to predict an approximative yearly production in natural forests.

/// Solution for a Resilient Future ///

Natural Aleppo pine forests, characteristic of Mediterranean landscapes, are home to a wealth of ecological and socio-economic resources that require an integrated, sustainable management approach. These forest ecosystems play an essential role in preserving biodiversity, protecting soils and regulating the water cycle. However, increasing anthropogenic pressures such as uncontrolled logging, fires and climate change are threatening the health and sustainability of Aleppo pine forests.

In this context, the adoption of appropriate management practices becomes imperative to reconcile the needs of conservation, sustainable use of forest resources and socio-economic development of local communities. Management practices in natural Aleppo pine forests should focus on promoting natural regeneration, controlling fires, protecting wildlife habitats, diversifying forest products, and enhancing ecosystem services.

This introduction aims to explore the management strategies and tools implemented in natural Aleppo pine forests, highlighting the management challenges specific to these Mediterranean forest ecosystems and the opportunities to ensure their sustainability and contribution to the well-being of local populations and the conservation of biodiversity. Helping forest owners and managers to better predict the annual cone and seed production in Tunisian Aleppo pine forests requires a major effort, starting with recent concluded findings such as:

- The wettest Aleppo pine forest area in Tunisia (sub-humid) presented the larger average cone length of about 74.2 mm, the larger cone weight of 27.3 g, and the smaller cone width of about 28.5 mm.
- The highest number of cones harvested per tree was also observed in the wettest zone with about 150 cones weighing 4.0 kg.
- The lowest number of cones harvested per tree was observed in the driest forest zone with 70 cones weighing 1.6 kg.
- The highest number and mass of seeds contained per tree or per cone was recorded in the wettest forest.



Main original products of mature Aleppo pine cones in Beja forests (North-Western).
Author: Abdelaziz Ayari | © Abdelaziz Ayari

- Mean individual seed mass was significantly higher in the driest Aleppo pine forest (arid climate).
- The only variable affected by latitude was the number of seeds per cone, with an increase of 16% per 100 km of northward forest movement.
- Average cone dimensions (width, length and mass) and average seed mass are negatively influenced by longitude as one moves from the Algerian forest border to the eastern sea coast, showing a positive continental influence on cone dimensions.
- An increase of 10% in cone width, 13% in cone length, 30% in cone mass, and 12% in average seed mass for each 100 km of westward forest movement from east to west.
- No effect of elevation gradient on mean cone dimensions and mean seed mass.
- The only significant effect of elevation is on mean seed mass.
- Average cone dimensions (width, length, and mass) and average seed mass were positively affected by elevation, indicating a positive elevation effect on cone measurements.
- An increase of 1.4% in cone width, 1.3% in cone length, 5.3% in cone mass, and 3.8% in average seed mass for each 100 m elevation.
- Due to the high variability among all sample plots, there is no aspect influence on cone and seed characteristics.

Effect of Bioclimatic Zones and Geographic Sites on Cone and Seed Properties and Their Impact on Seed Crops

Social demand of Aleppo pine's seeds has been increased in the last three decades (1990-2000-2010).



Main original Products of ‚mture Aleppo pine seeds in Beja Forests (North-Western).
Author: Abdelaziz Ayari | © Abdelaziz Ayari

- Cone characteristics (width, length, and mass) were closely related to the number of seeds produced per cone and per tree.
- The average cone length had a significant influence on the number of seeds per cone.
- Cone dimensions had significant relationships with stored seed mass per cone.

Seeds are needed to provide food resources to fauna and contribute for the survival of a wide variety of predators to maintain a biotic equilibrium with high biodiversity.

- The number and mass of cones per tree showed a highly significant relationship with the number and mass of seeds per tree.
- A decreasing tendency of cone yield and seed yield was found southwards, associated with a decrease in seed production for the individual means.
- Cone size (length and width) was less sensitive to elevation than cone mass.
- An eastward direction was negatively related to cone dimension and seed mass
- High intraspecific competition was observed in some stands, resulting in lower water availability, therefore affecting pollination, fruiting, and seed development.

/// Always Moving Forward ///

Forest managers use a variety of predictive tools and models to make informed forest management decisions. The tools needed by foresters and managers are presented here as predictive models (Table 1). Using these predictive models together with geographically sampled plot data, it's possible for forest managers to predict cone dimensions and individual seed mass. In addition, the cone measurements themselves could be used to predict per cone, seed number and mass. The cone size (width and length) prediction models using geographic parameters showed that altitude effects could have some importance in the absence of longitudinal or latitudinal gradients. The favorable influence of elevation on cone weight and size was attributed to better moisture conditions and lower temperatures, which induce higher photosynthetic rates and cone development.

Table 1. Predicting developed models for cone size and mass, single seed mass, in addition to the seed number and mass per cone and per tree.

Predicted parameters	Significant factors used	Predicting models
CW	Alt & Lgt	CW = 43 + 0.001 Alt – 3 Lgt
CL	Alt & Lgt	CL = 110 – 0.001 Alt – 9 Lgt
CM	Lat & Lgt	CM = 50 +0.03 Lat – 6 Lgt
SSM	Lat & Lgt	SSM = 40 + 0.0001 Lat – 4 Lgt
S#C	CW & CL	S#C = 50 + 2 CW – 3 CL
SMC	CW & CL	SMC = 0.05 CW + 0.03 CL – 2
S#T	C#T & CMT	S#T = 450 + 52 C#T + 1124 CMT
SMT	C#T & CMT	SMT = 5 C#T + 55 CMT + 5

where CW is Cone width, CL is Cone length, CM is Cone mass, Alt is Altitude, Lgt is Longitude, Lat is Latitude, S#C is Seed count per cone, S#T is Seed number per tree, C#T is Cone number per tree, SSM is Single seed mass, SMC is Seed mass per cone, SMT is Seed mass per tree, CMT is Cone mass per tree.

Similarly, forest inventory models where models use inventory data to estimate forest characteristics such as biomass, timber volume, species composition, etc. could help to monitor forest conditions and plan management. In addition, wildfire risk models where models assess of the risk and the probability of wildfires based on factors such as weather, topography, forest fuels, etc which could also help plan fire prevention and mitigation efforts.

Forest managers use a variety of predictive models to make informed forest management decisions.

Main Developed Prediction Models for Forest Managers.



Traditional Custard (Assidat zgougou) made of Aleppo pine tree grains as a main derivative seeds products in Tunisia.
Author: Abdelaziz Ayari | © Abdelaziz Ayari

Promoting the hypothesis proposed in the introduction, we achieved that: several factors showed a positive effect on seed cone production in Aleppo pine natural forest growing in North Africa. Higher moisture conditions in the studied bioclimatic areas resulted in higher cone and seed yields with a positive effect on fructification. The sub-humid ombroclimate showed higher mean values characterizing either timber importance or seed quantity per comparison to other bioclimatic areas. The geographical variability among the bioclimatic areas was embedded with latitudinal, longitudinal and altitudinal. Longitudinal gradient was the most determining geographical factor causing a marked increase in cone dimensions and its seed content, mainly in the semi-arid zone. High consistencies were found concerning terrain elevation with longitudinal effect in stimulating the species cone dimensions and seed quality.

It is important to note that the implication of the relationship in the geographical gradient could be in an opposite way depending on the physiological implications of movement, higher availability of nutrients, light and water and closer temperatures to the optimum are positively related to cone and seed quality and quantity. In the Mediterranean basin it is translated into higher rainfall and lower continental, so coastal and northern movements with lower altitude, in a low rate.

Several factors showed a positive effect on seed cone production in Aleppo pine natural forest growing in North Africa.



Tunisian yogurt with Aleppo pine seed savor as a second derivative seeds products in Tunisia.Author: Abdelaziz Ayari
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Authors: Abdelaziz AYARI | **Partners:** INRGREF – National Institute of Rural engineering research, Water and Forests

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The potential of Paulownia tree species for agroforestry systems and carbon sequestration

The Paulownia fortunei and Paulownia elongata potential in Tunisia and Portugal.



Paulownia introduced in agroforestry in Tunisia. Two months old plantation.
Author: Mouhamed El ayeb and Sonia Mbarki | © Mouhamed El ayeb and Sonia Mbarki

/// Context ///

In the Mediterranean region the need to consider new forest species for sustainable land management is faced and widely discussed, with particular relevance when aiming to promote the conversion of intensive agricultural land into agroforestry areas, and in the context of relevant social and climatic changes.

Paulownia, a species native to China and Korea that is commonly known as the imperial tree, encompasses nine species according to the most widely accepted taxonomic classification. These trees are cultivated worldwide due to their resilience to pruning and coppicing, drought tolerance, use as animal fodder, and their ability to support pollinators essential for honey production. Because of these characteristics, Paulownia trees are increasingly considered for inclusion in agroforestry systems.

While Paulownia tomentosa is known to be invasive, other species like Paulownia elongata and Paulownia fortunei do not share these invasive traits. These two species have recently been introduced and tested in Tunisia, where they have shown promise in reforestation and agroforestry efforts. Additionally, in urban environments, these trees contribute to reducing air temperature and pollution.

In Tunisia, several pilot projects have been launched to explore the adaptability of Paulownia species. Research focused on the Shantong variety has demonstrated its impressive carbon sequestration capacity, with organic matter content at 42% in leaves, 39% in stems, and 39% in roots. Biomass distribution studies revealed that stems accounted for the majority (about 65%), with leaves and roots each contributing around 36%. These findings highlight Paulownia's significant environmental potential across various applications.

Paulownia is a forest species native to China and Korea that has recently been introduced in Tunisia.

Tunisia is characterized by high spatio-temporal climate variability. This makes it one of the countries most vulnerable to climate change (MAE and Giz, 2011).

North Africa has limited resources and a long history of intensive farming may accentuate the problem of deforestation in the global rate of deforestation continues to increase and combing with the rising demand for timber products creates a critical need for forest management projects to satisfy the local market. The Paulownia tree provides a unique and ideal solution to this problem, with its rapidly developing root system, is an extremely suitable tree for afforestation of areas at risk of erosion, readily sustainable hardwood requiring minimal management and very little investment. These properties of the plant help in the re-afforestation of areas affected by climate change. From fostering thriving ecosystems to mitigating climate change, this practice offers a multitude of ecological, economic, and social benefits. Signifcant amounts of foliage provide good fertilization of affected areas. Wood also serves as a good material for composting; it is both rich and rapidly renewable trees are moving carbon from the atmosphere much more effectively than others; replacing more carbon-intensive materials – without mining or chemical processes improving soil health, water retention, and biodiversity in a country subjected to different deforestation for long decades as North Africa.

The genus Paulownia is grown around the world with common names including Empress, Princess, Foxglove, and Kiri tree. These trees are grown and loved for enjoyment and shade in gardens, and for lumber on tree farms. Unfortunately the Paulownia tomentosa, is a species of Paulownia that is included in the invasive species list. There are several other species of Paulownia that are not invasive, including the P. fortunei and P. elongata planted by the World Tree. This causes a lot of confusion and many assume the invasive qualities attributed to the tomentosa apply to all of the species, which was demonstrated in Tunisia is not the case.

Paulownia tree, a fast-growing tree species with considerable economic potential economic potential due to its high timber value, high biomass production andhigh stress tolerance.

/// Solution for a Resilient Future ///

The benefits of vitiforestry practices are multifaceted. Of notable importance are those in the area of:

Climate change mitigation
By integrating species like olives, pines, or oaks, winegrowers can significantly increase carbon stored in soil and tree biomass. In the long run, this improves soil health through organic matter from decomposed leaves and branches. Integrating trees with livestock grazing creates natural fire breaks around vineyards, reducing fuel loads and mitigating wildfire risks, which are increasingly common due to climate change. The 'Zebra', 'Donut' or 'Teardrop' approaches are some of the most common. Even poultry can play a role; they can eat grass/weeds, reducing pest pressure while fertilising the soil.

Climate change adaptation
Trees act as natural barriers against wind, protecting grapevines from hot, dry gusts that can desiccate grapes and reduce yields. This wind protection helps maintain a stable microclimate, reducing stress on the vines and improving grape quality. In spring, hedges, buffer strips or windbreaks provide essential frost protection by creating a microclimate that safeguards buds against late frosts. Such tree-based landscape features also shield grapes from extreme heat during summer months, mitigating the effects of heat waves and mega-droughts. The shade from trees helps maintain cooler temperatures, preventing early bud break and ensuring balanced sugar and acidity levels in grapes. The relevance of the microclimate is also reflected on the quality of the wines: tree transpiration refreshes the vineyard microclimate, maintaining humidity and lowering temperatures. This process can lead to higher-quality must with lower alcohol content and higher acidity, resulting in more balanced wines.





Fast growing tree can be used under climate change Year and a half old plantation.
Author: Mouhamed El ayeb and Sonia Mbarki
© Mouhamed El ayeb and Sonia Mbarki

Sustainable water resources
The root systems of trees enhance soil water retention by improving soil structure and allowing better water infiltration. This is particularly beneficial in Mediterranean regions facing water scarcity, as it reduces the need for irrigation and increases resilience to drought.

Soil, water, and atmospheric pollution
Vitiforestry reduces the need for chemical pesticides by attracting beneficial insects, birds, and bats that control vine pests naturally. This ecological balance promotes a healthier vineyard ecosystem and minimizes environmental impacts. Moreover, integrating trees contributes to a resilient soil microbiome, fostering beneficial microorganisms that help vines combat diseases like rot. A healthy microbiome enhances nutrient cycling and soil fertility, leading to healthier vines and better grape quality.

Protection of biodiversity and ecosystems
Vitiforestry promotes biodiversity by creating diverse habitats for various species. This integration of trees, shrubs, and cover crops supports a wider range of flora and fauna, improving pest control, pollination, and overall ecosystem health.

The circular economy
Vitiforestry offers opportunities for economic diversification through the sale of fruits, nuts, and timber from trees. Farmers can generate additional income streams, reducing reliance on grape production alone and enhancing financial resilience.

The Paulownia tree provides a unique and ideal solution for agroforestry challenge.

Domaine Vallot is one of the oldest domaines in the Côtes du Rhône (France). This vitiforestry system produces organic, biodynamic grapes for wine production.
Author: Domaine Vallot | © Educational use, non-commercial.



The Paulownia is becoming increasingly popular, not only because of its hardiness and indifference to soil quality wood, its ornamental and landscape value, but large leaves releasing oxygen.

Paulownia tree with high flower production is introduced in garden-forest (green space, Belvidere Tunisia).
Author: Sonia Mbarki | © Sonia Mbarki

Rural socioeconomics
Implementing vitiforestry fosters community engagement and education on biodiversity and sustainable practices. Local workshops and educational programs can raise awareness, encouraging more farmers to adopt these practices.
The integration of trees also enhances the landscape's aesthetic value, attracting tourism and promoting regions as destinations for recreational activities – as well as nature conservation, further supporting local economies.

Skills, policies, and generation renewal
Training specialists in area of vitiforestry is of particular relevance in the context of the high workload needed to manage such farming systems, and the shortage of skilled workers in agriculture. Digital tools and models are being developed to help winegrowers design optimal vitiforestry systems tailored to their local climate, soil conditions, and production goals. These decision support systems enable more informed planning and implementation of climate-smart agroforestry practices.

/// Always Moving Forward ///

The integration of Paulownia fortunei and Paulownia elongata into agroforestry systems presents several challenges, particularly concerning governance and ecological impacts. Although these species are not widely considered invasive, their introduction can still raise concerns about ecological balance and biodiversity in the Mediterranean region.

Governance Challenges
Effective governance is crucial for the successful management of agroforestry practices. A significant challenge is the inconsistency in regulations surrounding land use and forestry, which can create confusion among farmers regarding the legal implications of planting these species. Many Mediterranean countries lack comprehensive policies that support sustainable agroforestry practices, leading to uncertainty about the best management strategies. This regulatory uncertainty can discourage farmers from investing time and resources in the cultivation of Paulownia.

Environmental Considerations
While Paulownia fortunei and Paulownia elongata are recognized for their rapid growth and ability to improve soil health, there are ecological concerns associated with their cultivation. In particular, these species can have varying impacts on local ecosystems depending on their management.



Paulownia project in Northern Tunisia Grombalia, 2020. The plot covers 3.5 hectares with 725 trees. The trees are 6 months old and are grown under irrigation.
Author: Mohamed El-Ayeb | © Mohamed El-Ayeb

The ecological risks associated with introducing any non-native species necessitate careful monitoring. There is a concern that, without appropriate oversight, even non-invasive species can alter local ecosystems, disrupt habitat, and affect local biodiversity. For example, Paulownia trees, while beneficial for soil erosion control and improving soil quality, can shade out native plants if planted too densely or in inappropriate locations, potentially leading to reduced biodiversity.

Management Challenges

Proper management of Paulownia in agroforestry systems requires expertise and knowledge that may not be readily accessible to local farmers. Research and knowledge transfer on sustainable practices, such as optimal planting density, pruning, and pest management, are essential for maximizing the benefits of Paulownia. However, many farmers may lack access to training programs or extension services that provide education on these practices. This knowledge gap can lead to suboptimal management practices that could inadvertently cause environmental harm, even with non-invasive species.

Socio-Cultural Challenges

Cultural attitudes toward new agricultural practices can also present hurdles. In regions where traditional farming methods are deeply ingrained, farmers may be resistant to adopting new species like Paulownia, viewing them as unproven or incompatible with their existing practices. Community engagement and education are essential for overcoming this resistance and fostering a willingness to experiment with new agroforestry systems.

Highly profitable tree Production

Paulownia effectively combats global warming.

Climate change

The cultivation of Paulownia fortunei and Paulownia elongata faces significant climate-related challenges that impact their growth and productivity. In cooler regions, lower temperatures can slow down their growth rates, as these trees thrive best in warmer climates with temperatures consistently above 10°C (50°F). Frost events can also damage young trees, posing risks to their establishment.

In contrast, regions experiencing climate change, particularly those facing increasing temperatures and prolonged droughts, may see diminished growth rates and survival of Paulownia. Additionally, changes in temperature can affect flowering times and relationships with pollinators, disrupting reproduction.



High biomass plant production and fast growing under irrigated system.
Author: Sonia Mbarki | © Sonia Mbarki

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Authors: Mbarki Sonia, Samir Ghannem, Joana Amaral Paulo, Ahmed Boumenjel, Issam Touhami, Habib Kachouri, Samir Dahri, Ali Khorchani, Jeanne Chiche, Mohamed Tahar Elaieb | **Partners:** INRGREF – National Institute of Rural engineering research, Water and Forests

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ResAlliance

Barcelona Olive Oil: a social project recovers hundred-year-old olive trees hidden in Collserola natural park

The users of the Els Tres Turons Foundation, helping people with mental health issues, have found in the cultivation of olive trees a way to learn a profession and have the opportunity to stop being dependent.



Can Soler estate at the centre of the image (aerial photo of 2022).
Author: Institut Cartogràfic i Geològic de Catalunya
© Institut Cartogràfic i Geològic de Catalunya.



Can Soler estate, after its recovery.
Author: Fundació Els Tres Turons | © Fundació Els Tres Turons

/// Context ///

The city of Barcelona is wedged between the Mediterranean Sea and the natural park of the Collserola mountain range. Until the 20th century, these mountains were home to agricultural and livestock farms that were gradually abandoned and colonised by pine and holm oak forests. Together with urban expansion, the wildland-urban interface is continuous between the city of Barcelona and Collserola, with no agricultural area to act as a buffer, allowing fires to spread from the forest area to the urban area and vice-versa.

Recovering old crops is one way of breaking this wildland-urban interface. However, this is not commercially viable due to the small surface area of the plots and the slope of the land, which makes mechanisation impossible, and the absence of an entrepreneurial agricultural ecosystem in the city. A social project of community insertion for people with mental health problems has made it possible to reclaim abandoned olive trees groves that are hundreds of years old and produce the first olive oil in Barcelona in the 21st century. At the same time, these people have learned horticultural and forestry techniques, reduced their dependence on social services and increased their social integration.

/// Solution for a Resilient Future ///

The Can Soler estate is a communal facility located in the wildland-urban interface of Barcelona, at the foot of the Collserola mountain range. Managed by the Fundació Els Tres Turons (The Three Hills Foundation), the estate is bordered by pine and holm oak woods to the west and urban buildings to the east. It is one of those little-known places where vineyards, orchards and olive groves flourished until the middle of the 20th century to supply the city. In the middle of this green oasis, abandoned more than 50 years ago, the Foundation has been managing and improving the estate since 2009 with various projects, with the aim of becoming a reference point for urban agroecology and social inclusion by carrying out gardening and forestry activities of the public services of the Mental Health and Addiction Network, which aims to support young people and adults with a mental health diagnosis in their employment, training and social integration.

When the Foundation's staff began clearing the former farmland to reclaim more land, they unexpectedly discovered an abandoned olive grove. The olive trees had been unattended for more than 50 years, hidden by trees and bushes. At this point, the Foundation's technicians trained and guided people with social integration and mental health problems to clear the grove and prune the olive trees in order to resume olive production from these century-old trees, which takes several years after such a drastic change in the environment where the trees had grown.

With the 2023 harvest, they were able to collect enough olives of sufficient quality to produce extra virgin olive oil for the first time. And where can you buy it? Well, you can't, because it's for free. The aim of the small production is not to sell or make a profit, but to publicise the project and the Foundation's mission, as well as to educate and raise awareness about the promotion of biodiversity, agroecology and sustainable food. It has not been easy, but they have found a nursery where they sell

olive trees of the same variety, the becaruda, a type of olive that had almost disappeared. They want to plant more olive trees, not to produce more litres of oil, but to involve more people in the project.

The Can Soler recovery and revitalisation project is promoted by the Els Tres Turons Foundation, with the support of Barcelona City Council (Parks and Gardens Department and the Green Hands district initiative) and the Collserola Natural Park Consortium. The park envisages the recovery of traditional agriculture as one of the lines of action of its Special Plan for the Protection of the Natural Environment and Landscape.

The Can Soler project uses the Learning and Service methodology to enable the acquisition of skills and learning for the people served, while at the same time carrying out a community service task, in this case the regeneration of a space that was in a situation of significant degradation and abandonment. This has provided an opportunity to carry out significant processes of recovery linked to the territory for the people served by the Foundation.



Fundació Els Tres Turons' users tending centuries-old olive trees.
Author: Fundació Els Tres Turons | © Fundació Els Tres Turons



Can Soler oil is not marketed, but delivered to collaborating entities.
Author: Fundació Els Tres Turons | © Fundació Els Tres Turons.

/// Always Moving Forward ///

In the recovery of this agricultural landscape, citizens, neighbours, neighbourhood organisations, schools and people who use local facilities have actively participated in the project through cooperative work days. During these days, the fields were restored by removing invasive plants, the forest was cleaned and old dry-stone walls and adjacent paths were rebuilt. These days have also served to combat the stigma associated with mental illness, as the people receiving care have been the ones to dynamise the activities.

In a context of climate change and economic uncertainty, promoting local production is a commitment to environmental sustainability and food sovereignty. The Foundation's projects in Can Soler aim to be in line with this strategy, responding to the challenges faced by society, such as the loss of biodiversity or the climate emergency, while at the same time promoting more equitable and inclusive societies.

In addition to the public institutions mentioned above, the Foundation receives support and collaborates with the Catalan Health Service, the Catalan Department of Labour, Social Affairs and Family, and the Employment Service of Catalonia, all of which are part of the Catalan Regional Government, and the Department of Economy, Employment and Labour Insertion of the Barcelona City Council, among others.

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Authors: Eduard Mauri | **Partners:** EFI – European Forest Institute

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ResAlliance

Sentit: Recovering and enhancing the value of local agricultural products

Sentit is a project that uses gastronomic experiences as a way of disseminating the value of agricultural products and their associated transformation processes.



The color of the Extra virgin olive oil does not determine its quality. That's why in tastings they used dark glasses.
Author: Sentit | © Educational use, non-commercial.



Sentit brings people together around the eating table, and combines different types of olive oil with local agricultural products.
Author: Sentit | © Educational use, non-commercial.

/// Context ///

industry in Spain, Portugal and Argentina, she saw the need of (re)enhancing the value of our land, empower consumers through information, and create the (offline) social networks that are progressively being eroded. Sentit started off by offering consumers olive oil tasting and gastronomic experiences, but it is progressively expanding to other products through the collaboration with other professionals within the regional and national networks of the agrofood industry, such as fisheries, vermouth or coffee. By offering tailored experiences, Sentit seeks to create networks of both producers and consumers, but especially to turn the attention of consumers around the products that we eat, and what it makes them what they are. Be it the place where they are produced, the techniques and technologies used for their transformation (and how it affects the final product), or even their history. All in all – while taking the time of sitting down around a table, and rejoice of enjoying good food around good company.

/// Solution for a Resilient Future ///

The evolving landscape of agriculture and the global food markets are challenging the longstanding bond between commodity farming and rural development. Simultaneously, the rising demand for unique, high-value goods among consumers holds promise for fostering economic growth for rural communities, especially when linked with short value chains. However, it is often the case that potential buyers find high quality agricultural products too expensive. In this sense, Sentit seeks to bring the knowledge to the table, and bring consumers closer to the reality of the agro-food industry. It provides with information and first hand experience to get to know better and understand all those processes that are are needed to transform the primary to product to what we eat. And that are nowadays much more hidden for the final consumer than what they used to be.

Sentit puts on the table an innovative business model which enhances the brings a detailed knowledge of the olive oil value chain to end-consumers. It partners up with local olive oil producers and brings them to the table of different actors by delivering gastronomic experiences. These can be organized for private individuals (which are hosted in different spaces, including private homes, if available), but also for companies (as a way of team building, and often partnering up with restaurants that share its vision). However, Sentit also has also woven networks with public entites like FEDEPESCA (Spanish association of Retail Entrepreneurs of Fish and Frozen Products) and the Spanish Ministry of Agriculture. This particular partnership for example, one-day workshops are provided which discuss how olive oil may be combined with different fishery products. With the attendance of policy-makers, journalists and/or the general public these events have become excellent meeting points for discussing innovative ways forward for both the olive oil and fisheries sector.

Whereas Sentit has its roots in the olive oil, it does not limit to it and it is constantly seeking new alliances with

other projects and/or initiatives, both public and private, in which networks can be created and ultimately enhance the value of the products the initiative works with. Another example of how these networks are created is the synergy created with chef and graphic designer Maider Sorasu, for which together are putting together the initiative “Re. brotar” (Regrow). Similar to Sentit, together they seek to enhance sustainabily through conscious consumption in the Valencia region, working especially with companies and their employees. For the case of “Re.brotar”, and in order to overcome the challenges that entrepreneurs usually face when starting a new endevaour, they have participated in the accelerator programme Col.lab, facilitated by the Social Innovation Centre of the municipality of Valencia (Las Naves).

Sentit as a project started in September of 2019, when it delivered its first tasting. Its development has followed the same principle as the phylosophy of the initiative: Slow and steady. It is slowly consolidating as a reference in Valencia (Spain) and surroundings, as the perfect compliment for any gastronomical event that seeks to enhance the value of the local products, and bring together a group of people around a table of good food.



Irene Espert, the creator of Sentit, serves olive oil on bread in an olive oil tasting.
Author: Els Magazinos | © Educational use, non-commercial.



The Arauco variety of olives makes for a strong olive oil.
Author: Sentit | © Educational use, non-commercial.

/// Always Moving Forward ///

Sentit continues expanding. Whereas it could have been deployed at a much larger scale, Irene, its creator, decided to build it step after step, while combining it with a full time job. This has kept the project somehow small, but at the same time, it has allowed her to take the time that solid and trusting relationships take to develop. She is well connected to practically all small producers of olive oil in the Valencian region. They value her work and she is often invited to their events, to facilitate a workshop and conduct a tasting.

Simultaneously, Sentit is not in a hurry. It does not have a website for example, partly because it takes time to build it properly, and partly because it seeks to be self-sustained. In wants to be able to adapt and change on its own, not depending on externals. At the same time, Irene (or Sentit) knows that if she aims at enhancing the value of the food that we eat, and of the transformation processes required, she will need to continue weaving networks. And particularly those that link this initiative tightly to the city where it originated: Namely, the agroecology and food sovereignity networks thriving in the city of Valencia.

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Conversion of unproductive eucalyptus stands in Bragança, Portugal

A landowner is focusing on planting native cork oak species to convert unproductive and low-productivity eucalyptus plantations, taking advantage of the shade provided by some rows of the latter.



Landscape image of the properties when the conversion was initiating (2004/2005) | Author: JGA© | © JGA©

/// Context ///

In the context of climate change, the decline in productivity of some forest species is becoming an increasingly important issue. This is a problem that can be observed in several eucalyptus plantations in the Trás-os-Montes region of Portugal, such as the present case study in Bragança.

Planted in 1988, after ten years of growth, the volumes were estimated to be between 3.5 and 5 m³/hectare/year, a very low value for eucalyptus plantations intended for pulp production and therefore considered unproductive forest stands. Finding alternative forest management proposals based on forest species adapted to the edaphoclimatic conditions is a crucial contribution to landscape resilience.

In anticipation of greater profitability, it was decided to convert some areas to cork oak as the main species, at a density of 600 trees/hectare. The conversion is planned to be gradual in space and time, with only two in every three rows of the original eucalyptus plantation lines being removed. This not only guarantees the benefits of the remaining tree cover, particularly in terms of soil protection, but also provides shade for the new cork oaks, which is beneficial for the development of the species in the early stages of growth and particularly in view of the recurrence of extreme heat waves in summer. The conversion process involves various costs, including those related to the extraction of timber, the reconstruction of the land structure and the road network affected during the eucalyptus harvest.

/// Solution for a Resilient Future ///

In the northern region of Portugal, eucalyptus is the second most representative species, occupying around 164 thousand hectares. This area increased by 8.5% between 1995 and 2015. The great interest in the Eucalyptus globulus species is linked to its high profitability when explored for pulp production, and obtained with a rotation period of 9 years. However, the progressive change in soil and climatic conditions has shown that the productivity of eucalyptus is decreasing. In Trás-os-Montes, production values have been estimated between 9 and 12 $m^3\ ha^{-1}\ year^{-1}$. At present, however, it is difficult to find settlements with a productivity greater than 50% of these estimates made in the 1990's, and many areas are left without forest management, increasing the risk of forest fires spreading across the landscape. This was a problem faced by Quinta do Zimbro, a company responsible for managing a group of properties in the Bragança district.

The two forest inventories carried out during the first 10 years after planting (1988-1998) showed productivity values between 0.9 and 3.05 m³/hectare/year, well below the investment expectations. An alternative that has been tested on this farm, with the aim of improving the productivity of these forest areas, is the conversion of the stands to cork oak forest areas as the main species. The aim is to achieve, through gradual conversion, a cork oak forest with an average density of 600 trees/hectare. The conversion will be gradual, with only two out of three rows of eucalyptus trees being removed initially. Due to the reduced volume of eucalyptus wood suitable for pulp production, most of the removed forest biomass was incorporated into the soil. The remaining rows of eucalyptus will not be removed until 5 to 6 years later or later, depending on stand development. This strategy allows some forest cover to remain on the land, which protects the soil, but also increases the shade provided to young cork oak plants that grow in the space left by

the removal of the eucalyptus trees. This is an important factor for the survival of the young trees at an early age, and also for the formation of the straight trunks of the cork oaks that will be most suitable for mechanical harvesting of cork (a subject dealt with in another fact sheet).

During the first years, the development of the forest plantation will be evaluated according to the existing empirical and scientific knowledge of the cork oak. This will make it possible to draw up a technical plan to guide the management of the plantation and to define the most appropriate measures. One of the most important aspects is the monitoring of the nutrient potential of the soil. Although it is expected that the incorporation of eucalyptus harvest residues into the soil will have a positive effect in the initial phase, it will be necessary to assess the need for soil correction.

An initial fertilisation, based on a prior soil analysis, will ensure the minimum conditions for the positive development of the plantation. This is a particularly important operation given the difficulty in assimilating macro- and micro-nutrients due to the acidic nature of the existing soils. It is planned to use a compound fertiliser (P+K+4% MgO+B+32% Ca) Fertifos 021. The fertilisation will be carried out by covering and localised application of 100 g per plant. The aim of this fertiliser is to obtain the following benefits:

- Increased resistance to cold and frost (K).
- Encourage a rapid and vigorous start to the crop (P).
- Encourage root development without creating an imbalance with the aerial part, using a greater volume of soil (P).
- Promote the soil's ability to fix phosphorus, as it is a local fertilisation. When the local fixation capacity is saturated, immediate availability to the plant is favoured (P).
- Favours photosynthesis (Mg).
- Correction of calcium deficiency.
- Favoring the exchange complex (Ca).
- Stimulation of various vital phenomena (B).



Landscape image of the properties when the conversion was initiating (2004/2005).
Author: JGA© | © JGA©



Scope of the ResAlliance project's portuguese LivingLab (green). Location of Quinta do Zimbro, near Bragança. | Author: Paulo Firmino | © Educational use, non-commercial.

/// Always Moving Forward ///

Converting unproductive eucalyptus land into cork oak forests involves investment and maintenance costs that cannot be ignored. At the structural level of the land, the removal of woody material is a time-consuming and resource-intensive forestry operation. This operation will not provide a large volume of timber to fully recoup the investment in the short term, and the eucalyptus wood has a low demand in the region. In addition, in some situations it may be necessary to reinforce the soil as a result of this operation. The road network, which is in excellent condition, will also be affected by the operation and may require future repairs.

Interventions related to the establishment and maintenance of the stand include the use of individual protection, the replacement of dead trees, periodic soil analysis and the first fertilisation. The first few years after planting are monitored with technical rigour, so that a management plan can be drawn up in good time, taking into account the possible interventions that the species requires (e.g. formation pruning).

Due to associated limitations, the conversion has been gradually done, helped with financing obtained by submitting operational projects to funding programs (PDR2020, Fundo Ambiental) and the last Eucalyptus rows are expected to be removed in a near future.

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Partners: ISA – Instituto Superior de Agronomia

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ResAlliance

Innovative solutions in cork harvest operations: Mechanical cork debarking

In Sardinia, Italy, mechanical cork extracting technology is being used to preserve cork quality and improve working conditions for harvesters.



Example of use of the mechanical cork debarking machine (trials carried out in Sardinia).
Author: From the publication "The cultivation of cork oak"
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The cork debarking machine is combined with sensors capable of guiding it by measuring the different hydration of phellogen and cork.
Author: From the publication "The cultivation of cork oak"
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/// Context ///

Today, as in the past, the cork is debarked by pairs of harvesters using a special axe with a wedge-shaped handle; the workers mark the height of the two planks that are usually obtained from each tree with two ring cuts around the entire circumference of the trunk; the two rings are then joined by two straight vertical cuts. Detaching the two planks, which is done with the handle of the axe, is easy when the plant is in full vegetative activity and has an intense transpiration flow. The nature of the process and the tools used can make the debarking dangerous to the health of the plant: the incisions must not damage the phellogen, and this can only be achieved with great experience. The phellogen is the outer layer of the cork embryo and is essential for the health and growth of the cork tree. Damage to the phellogen can compromise the health and vitality of the cork tree and make it more susceptible to disease and damage, as the phellogen is involved in protecting the tree from environmental stresses, pathogens and pests. So, considering all aspects regarding safety and efficiency of this kind of work, the mechanical cork debarking method is a way under development to better manage the activity carried on cork trees lands in Sardinia.

/// Solution for a Resilient Future ///

In the early 2000s, a "mechanical cork debarking machine" appeared on the market, based on the use of a reciprocating blade combined with sensors capable of guiding it by measuring the different hydration of phellogen and cork. By using sensors capable of detecting the different hydration levels of phellogen and cork, the machine can guide the blade precisely along the boundary between the two layers, allowing more accurate and efficient debarking of cork; in addition, the ability to guide the blade along the boundary between phellogen and cork can reduce the risk of damaging the phellogen during the debarking process. This can help maintain the health of the cork oak and ensure cork regeneration in the future. By automating part of the cork debarking process and improving accuracy, this technology could enable greater efficiency in cork production, leading to higher quality cork production with fewer defects and greater uniformity: the machine, powered by an internal combustion engine, also fits into a "backpack" structure, making it backpackable and convenient to carry. According to the tests carried out in Sardinia, the machine allowed a 30% increase in working capacity over the course of the day, thanks to a constant working efficiency over time, while the productivity of the harvesters was higher in the first hours of work, but progressively decreased as the day progressed; the analysis of the cutting time alone showed a 35% loss in efficiency of the machine compared to traditional harvesting, due to the lower cutting speed. In terms of quality, the machine was clearly superior, as it did not

damage the phellogen in any way and produced perfect and even cut surfaces. This aspect is particularly important as it allows the use of inexperienced or unskilled workers on the corking sites. In addition, mechanical cutting allows the quality of the soft cork to be maintained, which in turn allows a higher remuneration to be obtained for the cork to be sold. In other production contexts, mechanical debarking of cork has become increasingly common. In Portugal, the world's leading cork producer, cork is an important economic resource and producers are constantly seeking to improve the efficiency and sustainability of the debarking process. The use of advanced machinery and technology for cork debarking is part of this effort, for example in Italy, in addition to Sardinia, there are companies in Sicily, Tuscany and Calabria that use mechanical cork debarking to improve harvesting efficiency and reduce production costs. However, it is important to note that manual debarking is still preferred in many areas of Italy, especially on small farms or in areas where soil conditions do not allow the easy use of machinery, for this reason the choice between manual and mechanical debarking often depends on the specific needs of the farm and the characteristics of the soil.



Cork extraction in Sardinia.
Author: Nicola Solinas | © Educational use, non-commercial.



Traditional cork extraction in Barrancos, Portugal.
Author: Paulo Firmino (ISA) | © Educational use, non-commercial.

/// Always Moving Forward ///

This technology appears to be a breakthrough innovation in the cork debarking process, with the aim of improving the accuracy, efficiency and overall quality of the cork produced. The use of mechanic machines can limit the damage to the phellogen, thus preserving the health status of the cork plant. The mechanised method allows the operators to work in better ergonomic conditions, since the postures and movements required for peeling are less demanding on the body than when using an axe. Finally, mechanical stripping allows for better safety conditions for the workers involved in stripping. Mechanical cork debarking is constantly evolving, pushing efficiency and sustainability: machines are still not feasible to use in adult trees with debarked branches, but it might be very useful for new cork oak plantations, where the trees are only debarked in the stem. Also, the machine can also be very useful in regions were highly trained workers are missing (even if training is needed also for the use of the machine). Obviously, a proper costs/benefits analysis is needed to suggest a large investment in this method, but the innovation of these machines can ensure the long-term sustainability of the cork industry and the conservation of valuable natural resources.

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Acknowledgment / Contribution

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Chapter 2

Associative Pratices

We've seen that the efforts from individual landowners are necessary, but landscape resilience can also be achieved and improved with the cooperation of multiple parts for common objectives. Associative practices are examples of how groups of forest managers, farmers, and other landowners can combine their knowledge, resources, and workforce to obtain outcomes that surpass the results from working individually.

These collective strategies often involve creating mosaic-like landscapes where agriculture, forestry are managed with complementary objectives. Associative innovations can reduce wildfire risk, restore degraded lands, and enhance biodiversity on a broader scale. Collaboration can also reach further results, as leading to the establishment of regional premium brands and markets that promote local products and therefore strengthen a sustainable land management.

The case studies in this chapter reveal how cooperation opens such possibilities. As examples, groups of landowners in Italy and Spain have been coordinating grazing regimes to reduce fire risk while strengthening their local rural economies. Also, in Tunisia an effort is being made to unite communities to restore ecosystems and guarantee the sustainability of common resources. Across several Mediterranean countries, these innovations show that landscape resilience is obtained both in the ecological and social scopes, based on trust, partnership, and common objectives.

The Associative practices chapter remind us that a landscape relies on large groups of different entities, and that joint management can be a tool to boost and maintain long lasting results.

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Type of solution: Management Sector: Forestry

Good practice(s): Ecosystems services, Protection against biotic and abiotic hazards

Forest Fire Risk: Mapping vulnerable areas in northeastern Algeria

Enhancing fire management through advanced remote sensing for predictive risk assessment and prevention.



Boutaleb forest, south of the Setif province in Algeria, before the wildfire of 2020.
Author: Aziz Ben Hamrouche | © Aziz Ben Hamrouche



Boutaleb forest, south of the Setif province in Algeria, after the wildfire of 2020.
Author: Aziz Ben Hamrouche | © Aziz Ben Hamrouche

/// Context ///

Forest fires pose an ongoing and complex challenge, increasingly threatening human life and ecosystems. In the face of this growing threat, better understanding and anticipation of these risks are becoming essential. In response to this growing need, remote sensing and geographic information systems (GIS) have emerged as essential tools in fire monitoring. They enable precise monitoring of environmental conditions and integration of data into predictive models, facilitating fire forecasting and the adoption of preventive measures.

Our study focuses on the development of a sensitivity map of fire-prone areas in the forest of northeastern Algeria. This involves the careful analysis of various criteria and factors influencing fire risk assessment. By exploiting GIS and remote sensing technologies, combined with the Analytical Hierarchy Process (AHP), our aim is to assign appropriate weights to these selected criteria. This approach aims to refine our understanding and management of forest fire risk by providing a rigorous and systematic methodology for assessing and mapping the susceptibility of areas to fire.

/// Solution for a Resilient Future ///

To enhance preparedness and adaptability to fire hazards in Northeast Algeria, we employed an innovative approach combining geographic information systems (GIS), remote sensing, and the analytic hierarchy process (AHP) to create a fire risk sensitivity map. These tools helped identify areas most prone to fires, facilitating the implementation of preventive measures and effective risk management.

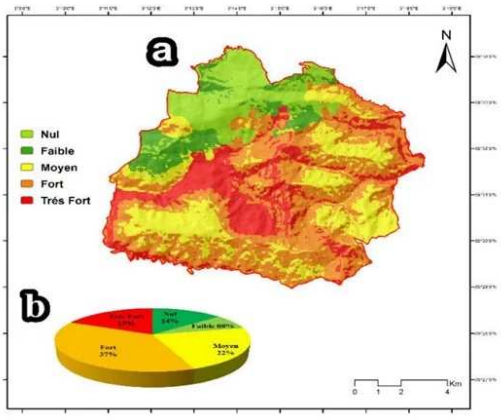
GIS is capable of processing and analyzing large spatial data, while remote sensing offers a comprehensive view of environmental phenomena. These technologies have enabled the monitoring of multiple factors influencing fire risk, such as vegetation cover, terrain, and climatic conditions. Using the AHP, we evaluated and ranked these factors according to their importance and impact. This approach contributed to identifying high-priority areas for monitoring and intervention. As a result, a detailed sensitivity map was created, showing the probabilities of fire occurrences in the targeted area.

This map is a valuable tool for decision-makers and emergency services, enabling them to identify the most fire-prone areas and efficiently direct resources and efforts towards those locations. Additionally, the map enhances public awareness of fire hazards and supports efforts to mitigate these risks. This study represents a significant step towards achieving a more resilient and safe future in the face of fire hazards, enhancing the local communities' capabilities to adapt and respond effectively to these challenges. By combining modern technologies with scientific analysis, we hope to provide sustainable solutions that contribute to protecting lives and the environment in Northeast Algeria.

The different stages of the study on the sensitivity of areas to the risk of forest fires in the North-East of

Algeria, concerning forest areas, can be detailed as follows:

- Identification of criteria and collection of spatial data: Identify the criteria that influence the study of the phenomenon of forest fires. These criteria include factors such as vegetation cover, topography, weather conditions and other relevant variables. Next, collect corresponding spatial data for each criterion, to use in the analysis.
- Using the AHP to determine criteria weights: Once identified the relevant criteria and collected the corresponding spatial data, the analytical hierarchy method (AHP) was used to assign weights to each criterion. The AHP allowed to compare the relative importance of each criterion compared to the others, taking into account the objectives of the study and expert opinions.
- Ranking the criteria on a single scale: Each criterion was ranked on a single scale, assigning values to indicate their sensitivity to wildfire risk. The least sensitive criteria received lower values, while the more sensitive criteria received higher values. This classification allowed to identify the areas most exposed to fire risk in the region studied.
- Final objective: Creation of a sensitivity map of areas exposed to fire risk.



Susceptibility Zoning Map for Forest Fires in Souhan, Algeria
Author: Aziz Ben Hamrouche | © Aziz Ben Hamrouche



Forest fires damage biodiversity and threaten the ecological balance.
Author: Aziz Ben Hamrouche | © Aziz Ben Hamrouche

/// Always Moving Forward ///

To effectively manage fire risk in northeastern Algeria, several key actions are required. Firstly, it is important to regularly update data on vegetation, weather conditions and terrain in order to accurately analyze fire risks. In addition, it is necessary to improve the monitoring infrastructure to obtain real-time information. By expanding the use of geographic information systems (GIS) and remote sensing, it is possible to cover larger areas and obtain a more comprehensive view of risks on a national scale. Training civil servants and raising public awareness of fire management and prevention is also essential. Strengthening cooperation between government agencies and organizations specializing in fire risk management will enable more effective strategies to be developed. It is also important to draw up detailed emergency plans and train specialized response teams for rapid, effective action. The use of modern technologies such as satellites and sensors for early warning is also recommended. Finally, scientific research should be promoted to develop innovative fire detection and prevention techniques.

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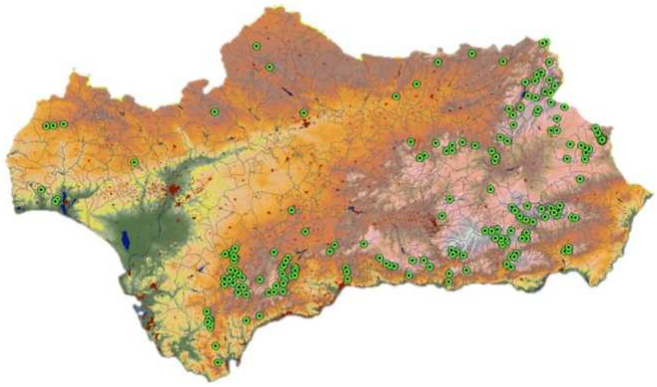
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The Andalusian grazing-firebreaks Network (RAPCA)

Targeted Grazing for vegetation control: The RAPCA network.



Location of Andalusia within Spain.
Author: Wikipedia | © Educational use, non-commercial.



Map of the firebreaks network in Andalusia.
Author: Junta de Andalucía | © Educational use, non-commercial.

/// Context ///

The RAPCA Network in Andalusia, Spain, known as the "Red de Áreas Pasto-Cortafuegos de Andalucía," focuses on using targeted grazing as a method for fire prevention and sustainable land management. This approach strategically utilizes livestock grazing to reduce vegetation, thereby creating natural firebreaks that help prevent the spread of wildfires. The network carefully selects areas for grazing based on their fire risk and ecological characteristics, ensuring a balance between fire prevention and environmental conservation.

In this system, livestock, particularly sheep and goats, play a multifunctional role. Beyond their traditional agricultural purposes, they are used as tools for environmental management, maintaining open landscapes that have lower wildfire risk levels. The RAPCA Network involves collaboration among farmers, environmental agencies, and local governments to effectively implement and manage these grazing practices.

Continuous monitoring and evaluation are essential components of the network, allowing for the assessment of grazing effectiveness in reducing fire risk and making necessary adjustments to optimize results. Overall, the RAPCA Network represents a sustainable and proactive approach to wildfire prevention, integrating traditional agricultural practices with modern environmental management strategies.

/// Solution for a Resilient Future ///

The Andalusian General Directorate of Management of the Natural Environment established the Network of Grazing-Firebreaks in Andalusia (RAPCA). This program utilizes targeted grazing to reduce biomass in specific areas, maintaining an appropriate forest structure to prevent fires. To encourage shepherds to graze their livestock in these areas, the RAPCA program offers monetary compensation as part of the payment for ecosystem services (PES).

Launched in 2005, the RAPCA program is a PES scheme in Andalusia that compensates sheep, goat, and cow shepherds for controlling biomass and maintaining firebreaks in public forests. The program prioritizes grazing in areas with existing fire prevention infrastructure, such as mechanically created firebreaks, and regions with a strong livestock tradition. This focus minimizes the need to relocate herds, build new livestock infrastructure like watering troughs and pens, and supports local economic activity. It ensures that livestock grazing aligns with comprehensive mountain management.

The shepherds who initially joined the program were instrumental in encouraging their peers and fostering trust with RAPCA staff. By 2010, the scheme was fully operational with 67 shepherds. By 2016, the RAPCA network covered 6,000 hectares, involving 223 shepherds from 189 livestock farms, with approximately 90,000 sheep, 20,000 goats, and 1,000 cows.

Technicians from the General Directorate of Management of the Natural Environment provide advice to shepherds

participating in the RAPCA program. Grazing is more intensive during spring and early summer to achieve the desired biomass reduction before the wildfire season. Livestock farmers decide the timing and methods of grazing to meet biomass reduction targets, reducing the need for costly monitoring. Shepherds declare the grazed areas, which are verified against the EU Common Agricultural Policy (CAP) Land Parcel Information System. Compensation for biomass control is based on the area grazed, success rate, and grazing difficulty.

The RAPCA program is managed by the General Directorate of Management of the Natural Environment and executed by the Andalusian Public Agency of Environment and Water (AMAYA). Livestock farms with grazing agreements on land owned by the Andalusian government or local councils are given priority for participation in public forests. Shepherds must sign an annual contract, taking responsibility for vegetation control in a designated area. RAPCA staff, employed by AMAYA, prepare contracts, coordinate involved agents, identify suitable grazing areas, and verify shepherds' tasks through periodic monitoring. They conduct pre-assessments in spring and communicate with shepherds throughout the year, performing a final assessment to ensure proper compensation.



Sheeps grazing in a firebreak.
Author: Junta de Andalucía | © Educational use, non-commercial.



Sheeps grazing under Pinus halepensis.
Author: Entretantos | © Educational use, non-commercial.

/// Always Moving Forward ///

When the RAPCA was conceived, there were virtually no similar initiatives in Spain, and few around the Mediterranean. Nowadays the PES scheme linking wildfire prevention and extensive grazing are gaining track, like the case of "Gran Canaria Pastorea", for which the RAPCA network was a model. The testing that took place two years prior its official launch was quite important, during which the public administration cooperated and received advice from the Spanish National Research Council (CSIC). For the development of the RAPCA programme, it has been essential for the technicians of the General Directorate technicians to acquire a deep understanding of the way shepherds work, their labour needs and the challenges they face. Including the infrastructure that they need in the areas where their animals graze. In addition, it takes special communication skills and empathy to be able to engage with shepherds and lure them into the RAPCA programme, since it is a job that entails a considerable degree of isolation. The work to improve the RAPCA programme is ongoing, yet it has definitely become a model in the Mediterranean context about how extensive grazing can be coupled with wildfire prevention services, and therefore with building more resilient landscapes.

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Type of Solution: Finance, Governance, Management
Sector: Agriculture, Agroforestry, Forestry
Good practice(s): Management alternatives, Ecosystems services, Financing, Protection against biotic and abiotic hazards

Building multifunctional mosaic landscapes using vineyards for wildfire prevention

Designing an Agroforestry Mosaic Landscape by Introducing multifunctional Vineyard Firebreak buffers for Wildfire Prevention in La Plana de Manlleu, Catalonia, NE Spain.



View of a vineyard in Pla de Manlleu biodistric (Catalonia).
Author: Angela Llop (Flickr) | © Educational use, non-commercial.



Vineyards acting as firebreaks in Mas Marés; Cap de Creus (Espelt Cellar).
Author: Anna Espelt | © Educational use, non-commercial.

/// Context ///

Rising temperatures and aridity in the Mediterranean Region have heightened wildfire risk and frequency, causing significant damage and expenses. Moreover, fire mitigation strategies often entail uncertain costs. Introducing firebreak buffers with low-flammability crops like vineyards in managed wildlands can mitigate wildfires while providing socioeconomic benefits, preventing rural depopulation, and promoting generational change. Furthermore, land use planning increasingly integrates complex agroecosystems to optimize ecological benefits and biodiversity conservation, aiming for economic-environmental balance.

In the Mediterranean region, the most widespread high-value crop is wine grapes. Pla de Manlleu (Catalonia, NE Spain) is a rural and mountainous area with large forest masses and vineyards, designated as a Biodistrict, which is an innovative form of territorial governance. The inhabitants of this area work towards improving the quality of their environment, work and products. The vineyards in Pla de Manlleu are renowned for their exceptional quality and environmental contributions. Raïm +500, a farmer association, cultivates grapes above 500 m altitude across three municipalities. Their objectives include defining, preserving, and promoting the territory. The group initiated a project to create buffers with vineyards to prevent forest fires in the designated Biodistrict. Collaboration with firefighters aims to integrate the project with planned action systems.

/// Solution for a Resilient Future ///

Vineyard buffers represent progress towards multifunctional landscapes, integrating well with ecosystems compared to traditional fire management methods. These agroecosystems offer ecological and economic benefits, supporting societal goals and promoting innovation in landscape design.

In this context, the Raïm +500 group defines the essence of the Biodistrict as the zone composed of all lands located above 500 meters above sea level that belong to the Plan de Manlleu (Aiguamúrcia) and nearby municipalities. Approximately 50 families live in this area, with 45 of them exclusively dedicated to ecological and sustainable viticulture. In line with the biodistrict's definition, the Raïm +500 Zone is committed to a coherent territorial model that is based on a homogeneous and compact natural area and is faithful to sustainability. The group focuses on three aspects:

(i) Territory, aiming to establish a well-balanced, profitable, and resilient agroforestry mosaic.

(ii) Cross-cutting economy, characterized by proximity and networking with other biodistricts and/or communities, with a clear emphasis on profitability.

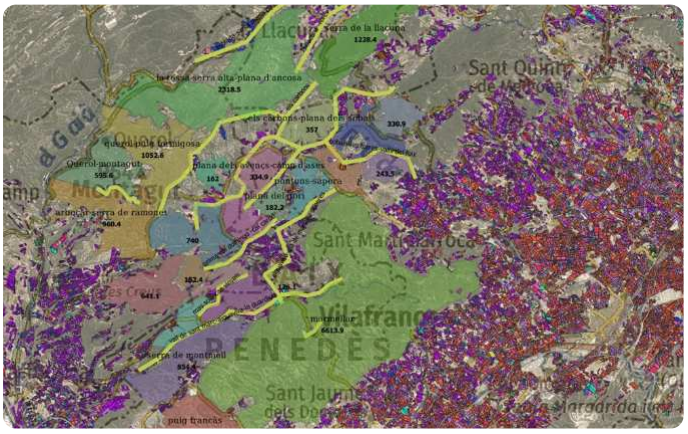
(iii) A vibrant and engaged community deeply rooted in and dedicated to the territory, actively safeguarding its heritage and well-being.

To foster the resilience of the mosaic landscape amidst the growing threat of wildfires exacerbated by climate

change, a project has been initiated in the Raïm +500 zone, later expanding to areas like Alts d'Ancosa. Initially, efforts focused on implementing the concept of mosaic agroforestry through forest maintenance initiatives and the collection of forest wood for composting or mulching in vineyards, aiming to sequester CO2. Subsequently, attention shifted to forest management primarily around vineyard firebreaks to enhance their efficacy. Collaborating with Catalan firefighters, it was observed that consolidating financial resources for forest management and path maintenance around these vineyard zones could improve accessibility for firefighters, reduce fire intensity, and facilitate control efforts from within the vineyard perimeters.

The firebreak buffers primarily consist of aligned cultivated fields, notably vineyards, serving as protective zones for residential areas and houses. In many agricultural regions, these buffers require consolidation and enhancement, sometimes integrated into road alignments and ridge paths.

Their designed forest mosaic comprises forested areas interspersed with vineyard firebreak buffers, with each forested area representing a maximum fire surface unit. This mosaic approach helps mitigate landscape devastation from fires, preserving the aesthetic appeal of the territory and sustaining its agrotourism and landscape value. It facilitates the identification of high-risk areas (such as Marmellar, Serra alta, Serra de la Lacuna) and pinpointing crucial locations requiring forest clearing or other costly interventions, given that vineyards are sustained by farmers if economically viable.



Mapping the planned vineyard firebreak buffers (lines in yellow) breaking forest masses in the Pla de Manlleu area.
Author: Raïm +500. Feature provided by Lluís Coll | © Educational use, non-commercial.



Catalan firefighters walking around the area affected by the fire in Cap de Creus.
Author: Diari de Girona; Aleix Freixes (ACN) | © Educational use, non-commercial.

/// Always Moving Forward ///

The success of the Raïm +500 initiative is evident as quality wineries are increasingly sought after, with selling prices surpassing those in the rest of the region. Notably, since the inception of the +500 project around 12 years ago, there has been a decline in the average age of winegrowers, indicating generational renewal. The project of using vineyards as fire barriers in Pla de Manlleu is still in its early stages, but its success in other Catalan regions underscores its feasibility. Mas Marès (from Espelt cellar) lands have effectively integrated agriculture and nature over the past two decades, forming a sustainable landscape and valuable agroforestry mosaic. They have created a resilient barrier against forest fires, with agriculture serving as a buffer zone, particularly shielding the urbanized area of Roses. Agriculture plays a vital role in establishing natural firebreaks, reducing fuel accumulation and enhancing fire management capabilities, as evidenced during the February 2022 fire. In Catalonia, initiatives like the Fire Wine project strive to enhance landscape resilience against wildfires, aiming to minimize losses. Specifically, this project will evaluate the innovation incentives within the wine sector's value chain.

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Acknowledgment / Contribution

A big thank you to Luís Coll from Raïm +500 for providing valuable insights into their initiative regarding the design of vineyard firebreak buffers and their farmer association in Pla de Manlleu.

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The Mosaic Landscape of Gran Canaria Island

A government initiative to reduce the risk of wildfires and promote sustainable development in the island.



Mosaic Landscape in Gran Canaria (Spain).
Author: Cabildo de Gran Canaria | © CC BY



Agricultural crops can act as"productive firebreaks" while being useful for suppression actions.
Author: Cabildo de Gran Canaria | © CC BY

/// Context ///

The wildfire regimes are changing in Gran Canaria (Canary Islands, Spain) as large wildfires (fires over 500 hectares) are now potentially more frequent, due to the abandonment of agricultural land, among others. This represents a very noticeable shift in the disturbance regime and poses a serious threat to biodiversity. Against this backdrop, the need for transforming the existing landscape to one with reduced fuel loads is acknowledged by all: practitioners, policymakers and researchers.

"Gran Canaria Mosaico" is the strategy for prevention of forest fires in Gran Canaria, put forward by the Cabildo (Government of the island). It promotes wildfire resilience in the island through the recovery of diverse ecosystems, including traditional activities linked to the primary sector, leading to less risky territories. The strategy represents a novelty insofar implements a more holistic approach to wildfire risk reduction compared to traditional wildfire prevention plans.

Its cornerstone is the understanding that the prevention of major forest fires is everyone's business. The strategy aims to recognise the central role of people, and especially rural inhabitants. During 2024, an award was created to recognise the work of individuals and organisations that contribute to forest fire prevention. Traditional examples: are carboneros (coal merchants), pinocheros (pine needle collectors), shepherds, and/or other businesses such as wineries or restaurants.

/// Solution for a Resilient Future ///

Policies to tackle forest fires have traditionally focused on hiring more and more firefighting resources to extinguish the flames. Paradoxically, the increase in firefighting effectiveness has led to a greater accumulation of forest fuel, a breeding ground for future large summer forest fires. On the contrary however, wildfire preventions plans often focus on preventive selviculture treatments such as firebreaks and/or roads and water points, which is only one small part of what a resilient landscape should be.

Gran Canaria Mosaico offers an alternative approach: It fosters multiple activities that aim at reducing the vulnerability of the island in a long-term, sustainable way. It provides a common framework for a wide range of wildfire prevention tools, which provides with a multi-dimensional perspective to wildfire prevention in the islands. Taking the website as an example, it is possible to see how it provides with information about:

- Prescribed burns.
- Procedures to request permission for agricultural burns.
- Information about the different types of forestry activities in the island and the regulations needed.
- What are the green breaks of laurisilva forest and their importance for wildfire prevention.
- Silviculture treatments carried out by the Cabildo.
- Instructions to the general population about what to do in case of fire.
- The extensive grazing programme "Gran Canaria Pastorea"
- General preventive measures that the general public should take into account for self-protection.

One of the most remarkable ones and that we will highlight is the “Gran Canaria Pastorea”, which is a payment for ecosystem services scheme (PES) for shepherds. Gran Canaria Pastorea is a project launched by the Cabildo of Gran Canaria to prevent forest fires by using traditional grazing practices. It assigns grazing areas in public forests and ravines to local shepherds, who are financially compensated for helping reduce fire risks by maintaining the land. This helps to further create a mosaic landscape across the islands, where a mix of agricultural fields, open areas, and forests can act as natural firebreaks, slowing the spread of wildfires.

In 2022, the project had 35 shepherds as part of the programme, who were managing 2,018 hectares of pastures with 6,750 goats and sheep. The payments they receive range from 20 to 180 euros per hectare per year. Mantaining extensive grazing in the island also contributes to the conservation of the traditional cheese industry, prepared with raw milk and which are renowned worldwide. The initiative helps preserve the environment and supports local pastoral traditions while contributing to fire prevention.



Example of a map showing the permitted areas for collecting pine cones and pine needles.
Author: Cabildo de Gran Canaria | © CC BY



Consuming locally produced cheese is one way of removing fuel from the landscape.
Author: Cabildo de Gran Canaria | © CC BY

/// Always Moving Forward ///

Even though the Payment for ecosystem services scheme for shepherds is one of the most well known pillars of Gran Canaria Mosaico, it is important to remember that the strategy is broader in scope. It is, in fact, an evolution of a more “classic” wildfire prevention strategy of the island, to which the government of the island decides to provide with its own brand and its own direction (to link land management and wildfire risk reduction to the enhancement of the value of local products). The brand Gran Canaria Mosaico has evolved and has a very important social value, therefore there is a lot of attention being paid to communication with the broader public, including at schools with kids.

At the moment, the funding for Gran Canaria Mosaico is 100% public. However, the intention is to progressively expand and find the right structures and mechanisms so that private funding can also contribute to it. Understanding that building resilience in the island cannot be only the responsability of the public administration, but also of several other stakeholders. In this regard, the responsibles of the strategy are exploring how carbon credits or CSR (Corporate Social Responsability) can also support the activities that are needed to build a resilient island. The first step is to expand the PES scheme beyond extensive grazing, and also support other traditional activities (carbon merchants, or collectors of pine needles), as well as farmers that cultivate their land in strategic areas.

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Acknowledgment / Contribution

We are grateful to Dídac Díaz for his availability, and for providing the information to complete this factsheet.

Authors: Carmen Rodriguez | **Partners:** EFI – European Forest Institute

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Type of solution: Management Sector: Forestry

Good practice(s): Management alternatives, Protection against biotic and abiotic hazards

Wildfire prevention at communal scale through annual interventions of territorial preparation

Implementation of a replicable format for wildfire prevention carried out in the municipality of Bonorva, Sardinia, Italy.



Figure 1. Simulator output used to tailor fuel treatments. If fuels on the blue lines are eliminated the area between the blue and the red lines is not burned.
Author: Franco Casula, Tesei Giovanni | © CFVA

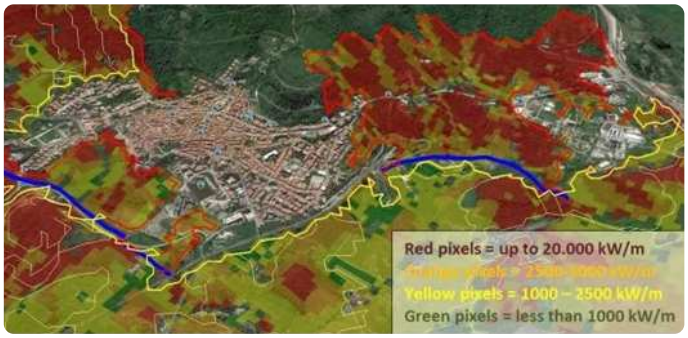


Figure 2. Simulated Fire Line Intensity (FLI) [kW/m]. The FLI is an important factor for firefighters as it conditions the possibility to directly attack the firefront.
Author: Franco Casula, Tesei Giovanni | © CFVA

/// Context ///

Despite significant progress in judicial repression and an efficient and powerful firefighting apparatus, the island of Sardinia, one of the most fire-prone areas in Europe, continues to experience serious problems with extreme wildfires, both in terms of magnitude and related losses.

To attempt to solve this problem, we propose a methodology for designing and implementing a strategic oriented plan of mitigation actions. It involves a first preliminary studying phase of landscape/fire regime characteristics, the identification of areas and actions to carry out, and then the optimization of the treatments through the use of a fire spread simulator. The final phase is the fuel reduction treatment on the identified small but strategic areas. The developed methodology was already validated at municipal level in Bonorva (Sardinia – IT), where the study phase allowed to finally carry out tailored interventions on biomass contiguity, thus optimizing the area treated and the actions effectiveness in maximizing wildfire risk reduction.

Bonorva municipality was affected by large wildfires in the past years, with critical points at the rural-urban interface (WUI). This case study describes a fire prevention approach devised by the Group of Analysis and Use of Fire of the Corpo Forestale (GAUF-CFVA), together with the National Research Council – Institute for Bio Economy (IBE-CNR) and the Agency Forestas and carried out thanks to the collaboration of the Municipality of Bonorva.

/// Solution for a Resilient Future ///

The methodology develops, tests and implements consistent planning for wildfire prevention, with actions strategically oriented to the reduction of the fuel load and horizontal and vertical contiguity, creating a flexible format that can be adapted to fit the local characteristics in most of the contexts. The analysis of landscape, climate and local fire regime characteristics and the use of a wildfire propagation simulator (Figure 1), allow operators to identify key areas for prescribed burning, strategic grazing and prevention forestry. The methodology includes four steps:

1. Preliminary study: Characterization at the territorial scale of landscape features, climate, vegetation/fuel, urban features, local fire regime, and territorial peculiarities is essential to define objectives and identify critical issues. As a result of this step, four main criticalities have emerged for the municipality of Bonorva: the WUI problem, the wind farm area, the Mariani nature park, and the Santa Lucia plain, which is frequently traversed by large fires.
2. Planning the actions: The information collected in the first phase drives the different operational interventions hypotheses. The choice is refined through a wildfire propagation simulator, used to:
   - Identify key areas of intervention for prescribed burning, strategic grazing and preventive forestry actions;
   - Guarantee the optimal compromise between the minimization of treated surfaces and the maximisation of risk mitigation.

   The fire propagation simulations were carried out with SWS (Sardinian Wildfire Simulator), a software developed by IBE-CNR, consisting of a modelling chain for real-time spatially explicit simulated forest fires propagation. In particular, the Action Plan developed for Bonorva identified four lines of intervention for risk mitigation:
   - Fuel reduction at the interface, by winter controlled burnings of bramble (Rubus sp.) and other brushes adjacent to the houses and late spring burnings of grasses (Figure 2);
   - Enlargement, by late spring controlled fires, of the street net in “Piana Santa Lucia”, where the wider fires usually spread. The net act as firebreaks and anchor points to set backfires in case of fire;
   - Partitioning of fuels under the wind farm by creating separated sectors to facilitate firefighting strategy and tactics that must take into account that on those areas the aerial intervention is impossible;

- Creation of a firebreak to protect the “Parco Mariani”, using controlled fires and preventive silviculture techniques.

3. Engaging the community: The local community is involved by means of communication, information, training and education measures aiming to raise risk awareness and stimulate an active approach to mitigation. Eventually, as in the case of Bonorva, the municipal administration can issue an ordinance stating the need to mitigate the risks, which allows the operators to carry out the actions included in the plan, disregarding land ownership (Figure 3).

4. Carrying out the actions: Finally the action plan is carried out and wildfire risk is reduced. A cost-benefit assessment can be carried out aiming to evaluate the balance between prevention and response and possibly confirm what is reported in literature, i.e. that prevention is more cost effective than firefighting (Figure 4).



Comune di Bonorva
Provincia di Sassari
Ufficio Tecnico

ORDINANZA PER L'APPLICAZIONE DELLE MISURE DI PREVENZIONE RISCHIO INCENDI - ATTIVAZIONE PIANO DI AZIONI DI PREPARAZIONE TERRITORIALE PRIMAVERA 2023

Ordinanza n. 01 del 05 aprile 2023

* * *

Il Responsabile del Settore Tecnico

VISTO, l'art. 107 del d.lgs. n. 267 del 18 agosto 2000 in materia di attribuzione di funzioni e responsabilità delle figure dirigenziali dell'ente

VISTO, il d.lgs n. 1 del 2018 "Codice di protezione civile" che all'art. 16, comma 1, individua il rischio incendi boschivi quale tipologia di rischio di interesse del Servizio Nazionale di protezione civile;

Figure 3. Mayor’s order for conducting controlled burnings on private properties.
Author: Franco Casula, Tesei Giovanni | © CFVA



Figure 4. GAUF of CFVA conducting the controlled burnings at the interface of Bonorva.
Author: Franco Casula, Tesei Giovanni | © CFVA

/// Always Moving Forward ///

The methodology is designed to be adopted by public administrations at the spatial planning level for the setting up and maintenance of “passively safe landscapes” through annual territorial preparation: according to the Italian Civil Protection Code, this type of intervention is considered “structural prevention.”

This type of intervention requires the definition of clear and shared objectives with the population, which plays a decisive role in the success of prevention interventions.

The widespread dissemination of similar projects contributes to the creation of “fire-smart” territories where the fire-fighting apparatus is enabled to control wildfire events because prevention works carried out on fuels are the way to avoid extreme wildfire behavior.

Moreover, literature reports that prevention is 5-7 times cheaper than firefighting, 1 euro invested in prevention saves ~5-7 euro in firefighting, damage and restoration.

This pilot case carried out in Sardinia by public administrations aims to create a format that can be replicated by other local communities, as the depopulation trend forces new ways of managing territories.

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Acknowledgment / Contribution

The project was conceived within the specialised Group of Analysis and Use of Fire of the Corpo Forestale (GAUF-CFVA), and the support of: Comune di Bonorva, National Research Council – Institute for Bio Economy (IBE-CNR) and Agenzia FoReSTAS

Authors: Franco Casula (Regione Sardegna), Tesei Giovanni (CFVA), Sara Maltoni and Mauro Forteschi (FoReSTAS).

Partners: FoReSTAS – Agenzia forestale regionale per lo sviluppo del territorio e l’ambiente della Sardegna

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Prescribed burning for restoring habitat and boost local products in European dry heathland with abundant Erica scoparia

The LIFE Project "GrAnATHa" developed sustainable solutions for environment and local economy in the special protection area 'Pratomagno pastures and mountain bushes' (Italy).



Prescribed burning action during the LIFE project GrAnATHa development.
Author: D.R.E.AM. Italia | © Educational use, non-commercial.



Pratomagno area with Erica scoparia cover.
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/// Context ///

The aim of this action, which was initiated by a previous LIFE project, is to improve the conservation status of bird populations associated with mountain heath habitats (habitat 4030 'European dry heathland' with abundant Erica scoparia) found in the special protection area 'Pratomagno pastures and mountain bushes' (IT5180011), located in central Italy.

In the past, these areas were used for traditional activities such as broom production. However, due to abandonment, they are now developing different vegetation types, with the growth of trees and shrubs leading to the eventual establishment of a forest. Unfortunately, this transformation has resulted in the reduction of an important habitat for the reproduction of many bird species of conservation concern, which are listed in Annex I of DC 2009/147/CEE. Restoring open areas can help to conserve protected bird species, and using the vegetation for broom production can prevent forest fires.

Mechanical treatments and prescribed burns have been used to manage 172 hectares, resulting in an increase in the presence of pairs of protected bird species within 4-5 years of the project starting. Ninety-nine per cent of Erica scoparia heather stumps have regrown, and prescribed fire management has resulted in faster regrowth. Thirty per cent of the 172 hectares are privately owned and a cooperative of local people now has a 74 hectare concession for broom production.

/// Solution for a Resilient Future ///

While wildfires have historically affected areas with fire-prone Mediterranean species, such as Erica scoparia, they have also played a critical ecological role in shaping several different types of Mediterranean landscapes. Recovering and maintaining the use of fire as a tool therefore provides an opportunity to manage the landscape with a nature-based solution.

Prescribed burning interventions may be conducted in natural areas with difficult access for mechanical means, where other economic activities are not possible. In addition, this action also serves as training for personnel involved in both prescribed burning and firefighting during fire season. Prescribed burning works provide an ideal situation for updating and providing practical training to those asked to fight wildfires.

The project aimed to develop a solution that allowed to carry out conservation actions to halt and reverse the trend of land abandonment in heathlands (habitat 4030), observed in the special protection area 'Pratomagno pastures and mountain bushes', located in central Italy. This was achieved by restoring the ecological functionality, mainly through the removal of invasive trees and shrubs,

and creating conditions for the reestablishment of Erica scoparia populations, and the local production of brooms and other tools made from this species. This solution is expected to ensure continuous and long lasting management of heathlands, while promoting economic activities from local communities.

A total of 172 hectares were managed using mechanical treatment or prescribed fire. These areas are important for many bird species, and this action has resulted in an increase of the presence of protected bird species pairs within a 4 to 5 years' period. Ninety-nine percent of Erica scoparia heather stumps present in this area have regrown, and prescribed fire management resulting in an observed faster regrowth. Private individuals own thirty percent of the 172 hectares, and a cooperative made up of local people now has a concession of 74 hectares for broom production.

Other positive impacts of using this forest management tool include biodiversity conservation, reducing fire risk, limiting the growth of flammable biomass, and preserving the historical-cultural landscape of mountain areas through socio-economic means.

The project succeeded in contributing for the improvement of the conservation status and increase the populations of bird species by restoring and enhancing their nesting and feeding habitats.

Additionally, it aimed to establish a local production chain for tools made with Erica scoparia (brooms), and the identification of an alternative model for managing and using heathlands that ensures stable conditions for species reproduction.



Brooms production.
Author: D.R.E.AM. Italia | © Educational use, non-commercial.

GR-AN
-A-T-H
GRowing AviaN
in Apennine's Tuscany
HeathlAnds

LIFE project GrAnATHa logo.
Author: GrAnATHa project | © Educational use, non-commercial.

/// Always Moving Forward ///

The GrAnATHa project has been a preparatory action for starting up an economic activity that can create income in disadvantaged and marginal areas. This can have a positive impact on the social structure of mountain areas, contributing to limiting depopulation. The project integrates fuel management in a high fire risk area with habitat restoration, serving a dual objective.

The aim is to promote the growth of heather while reducing the spread of invasive tree and shrub species. To achieve this, it is recommended to rejuvenate heather forests that have not been cut for a while, creating a mosaic of areas with different heather forest structures that favor avifauna. This practice can be replicated in all territories where there is an interest in specific fire effects, such as reducing fire hazards, regenerating forests, restoring habitats, and maintaining pastures.

To sustain the project's activities and ensure its success, it is essential to have well-trained, sensitive and skilled fire management personnel to achieve the objective of creating a sustainable economic activity linked to landscape management. The broom cooperative will continue its activities after the end of the project.

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Authors: D.R.E.Am. Italia (Sbaragli, Galfré, Miozzo, Martini) | **Partners:** D.R.E.AM. Italia

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Volunteers for wildfire prevention and suppression in Catalonia (Spain)

Forest Defence Groups, or ADFs, are volunteer associations, funded by the regional government, that operating in Catalonia carrying out mainly out wildfire prevention and suppression tasks.



ADF volunteers collaborating with firefighters.
Author: SFADF | © Educational use, non-commercial.



ADF Volunteer carrying out fire prevention tasks.
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/// Context ///

The Catalan Forest Defence Groups (or ADFs) were formed by pagesos (Catalan farmers) who traditionally assisted each other in protecting their farming and forestry properties from wildfires. In 1986, a regional law (Executive Order) was passed to regulate the establishment of these groups and their objectives, which include supporting fire prevention, fire suppression control, and post-fire reforestation. Nowadays they operate in the majority of the Catalan territory, although their presence is more important in rural areas. They have gone from informal, loosely connected network of people in Central Catalonia in the 1960s and 1970s, to a highly organized network of more than 3000 volunteers operating throughout the Catalan territory. The presence of these groups in their area of influence, their awareness raising activities of the risks of forest fires, and their engagement with local inhabitants, local institutions and fire and forest management bodies, constitute a highly effective governance mechanism in Mediterranean regions, which has shown to be effective in enhancing wildfire resilience.

/// Solution for a Resilient Future ///

The ADFs have their origins in the networks of mutual help and forest owner associations that have been operating in the area since the 1960s and 1970s. This type of collective action was mainly carried out by Catalan farmers (who also owned forestlands), and was particularly well-organized in Central Catalonia, where the risk of wildfires is very high. Back then, firefighting bodies were primarily urban and lacked the appropriate means to tackle forest fires efficiently. Therefore, these local networks were invaluable for local communities in extinguishing fires that affected their properties. It was against this backdrop when forest owners' associations were first established in the 1960s and 1970s, to address the need for mutual aid and cost-sharing in fire suppression. During that time, firefighting was not yet a public service, and forest owners were responsible for covering the expenses of firefighting assistance.

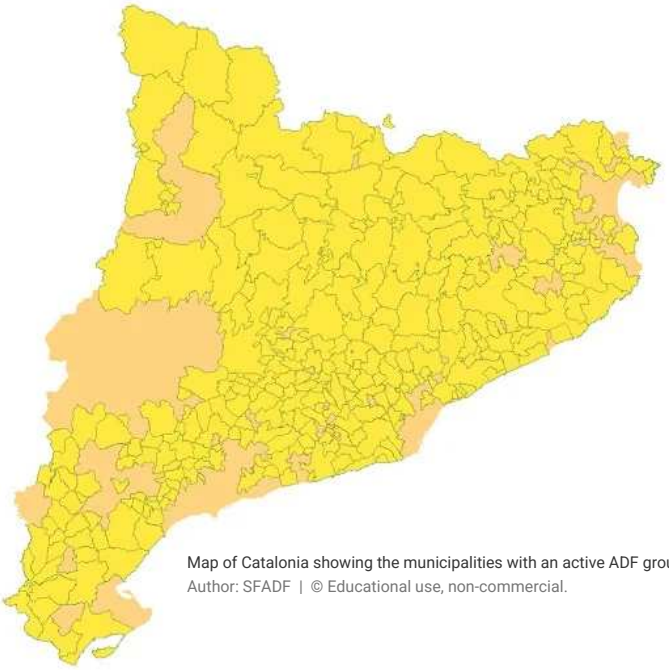
It was also during that time when a diverse group of local stakeholders (land owners, union members, citizens, local authorities among others) started meeting to explore potential solutions. The municipality of Manresa provided for a meeting space that effectively served as a forum hosting societal dialogue on wildfire risk. One of the main concerns raised was the lack of resources available for wildfire suppression. Despite the lobbying efforts, it was not until the Mountain of Montserrat burned, in August 1986, that the issue received sufficient attention from the regional government. It is important to mention the important aesthetic, environmental and religious values ascribed to this mountain by Catalan society. Consequently, the Montserrat wildfire triggered a strong response not only from the local population but also from urban citizens, prompting protests against the government, and therefore pushing the issue from one of local concern, to one with a regional scope.

Only a couple of months after the Montserrat fire, in October of 1986 a law was passed that constituted the ADFs as a specific type of associations, registered by the

Catalan government and eligible for specific funds. Over time, their role within the Catalan fire prevention and suppression system was consolidated, mainly through the Catalan Forest Law (1988), the Wildfire emergency plan (1994) and wildfire prevention plan (in 1986 and then in 1999). Nowadays they are a network of over 3000 volunteers that work on surveillance, wildfire prevention, support to firefighting during emergencies, awareness raising and restoration of burned areas. They are also regularly trained by professional firefighters, thus providing the volunteers with basic, yet state-of-the-art knowledge on wildfire management. Additionally, they collaborate with other local organizations, therefore contributing to the strengthening of the social fabric in the areas where they operate.



Mountain of Montserrat.
Author: Albert Garduño | © Educational use, non-commercial.



Map of Catalonia showing the municipalities with an active ADF group.
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/// Always Moving Forward ///

ADF volunteers have a strong emotional connection to the territory. This connection is an important source of resilience because it stirs engagement among those concerned with environmental stewardship. In order to adapt to present and future challenges, it is crucial to mantain and promote these connections between civil society and the natural spaces they inhabit. The history of the ADFs shows the importance of having a governance system in place that is inclusive, and actively stimulates the participation of all concerned actors. Facilitating exchange between firefighting professionals, land managers and volunteers with different types of expertise. This not only allows to increase the workforce, but also paves the way to collectively address politically sensitive issues. In a situation of high uncertainty and severe wildfire events, it is important to increase the space for these activities, which affect large sectors of society, but also intersect with other challenges faced by Mediterranean, fire-prone territories and societies such as drought or rural abandonment. One of the key reasons why this solution has worked successfully over more than 30 years it's because it has been able to pair traditional ways of doing, with state of the art know-how provided by professional firefighters and technicians, as well as the resources provided by the public administration. In this regard, ADFs provide a clear example of how the provision of resources (e.g. funding, equipment and training) and assignments to communities can have a significant impact on shaping local realities, particularly in the context of global change scenarios and heightened wildfire risk.

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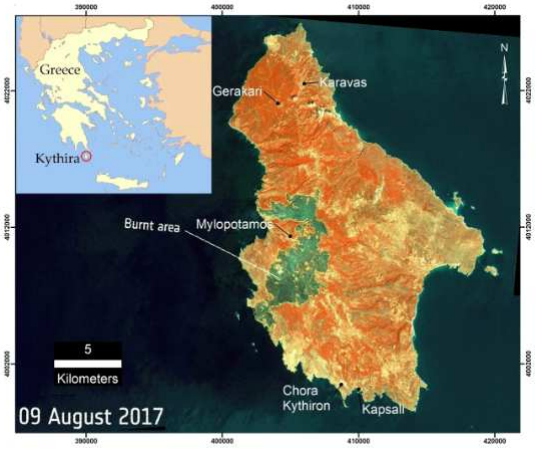
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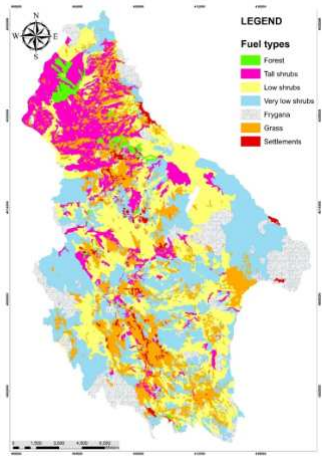
ResAlliance

Forest fire prevention in Kythira island, Greece, through mobilization and cooperation of the population

Properly informed and mobilized citizens can help avoid fire starts and reduce damages. A project in Kythira island offers a good example.



Annotated false color composite image of Kythira, captured by the Copernicus Sentinel-2 satellite pair, immediately after the 4 August 2017 fire.
Author: Copernicus Sentinel Hub | © European Space Agency



Kythira forest fuel types map.
Author: Institute of Mediterranean Forest Ecosystems
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/// Context ///

Fire prevention is a complex task with a very important role in forest fire management. In remote places, such as Kythira island, with limited local firefighting resources, difficulties in transportation of ground reinforcements and delays in the arrival of aerial support due to distance, the role of fire prevention becomes critical. An in-depth analysis of fire statistics on the island, followed by documentation of significant past fires that was achieved by a detailed search in the archive of local newspapers, were used to make citizens aware of the problem and motivate them to contribute to fire prevention efforts. A key element of the project was harmonious cooperation of specialized scientists from the Institute of Mediterranean Forest Ecosystems (IMFE) of the Hellenic Agricultural Organization Dimitra and the Hellenic Society for the Protection of Nature (HSPN), with volunteering citizens of Kythira. The volunteers, with the need for prevention evident and under the guidance of the scientists, were mobilized, offered many ideas and devoted considerable time and effort to organize and carry out various activities. The most important overall outcome was an improvement of the overall picture: in the years that followed the 2017 disaster forest fires did not become an issue on the island again, although Greece faced two fire disaster years in 2021 and 2023. Of course, there have been fire starts but the number is much smaller. The average yearly burned area decreased sharply as there have been no major fires, and there have been no damages to structures.

Working with the local population on forest fire prevention for effectiveness and efficiency.

In remote places, such as Kythira island, with limited local firefighting resources and delays in the arrival of reinforcements due to distance, the role of fire prevention is critical.

The project demonstrated the possibility to improve fire prevention and reduce damages through education and mobilization of the population. This was achieved at a very low cost and included fuel hazard reduction carried out by volunteers at a few critical forest locations, while many locals invested effort to reduce the risk to their homes. However, all this did not happen spontaneously. There has to be a spark for such an effort to start and continue and there needs to be credible scientific guidance which, in this case, was offered by the scientists participating in the project.

The fire prevention effort did not happen spontaneously. There has to be a spark for such an effort to start and continue and there needs to be credible scientific guidance and involvement.

/// Solution for a Resilient Future ///

Smart fire prevention solutions are necessary in small islands and other remote places in Greece. As the population is small and resources are limited, it is necessary to ensure that everybody is mobilized to reduce fire starts and prepare for the case of a forest fire that may burn for hours without adequate firefighting. On Kythira island this harsh reality became obvious when, in August 2017, a large fire burned nearly 10% of the island, causing damages and scaring locals and summer tourists. Soon after the fire, HSPN started efforts to turn the fear and anger of the people in a positive direction. "The Trip for the Regeneration of Kythera has started…" was an initiative about the rehabilitation of the island after the fire. In its efforts, HSPN requested the expertise and support of the researchers of IMFE. The two partners soon secured funding from the Green Fund of the Ministry of Environment and Energy for a low-cost project named "Innovative Action for fire prevention in Kythera through mobilization and cooperation of the population". The project aimed to mobilize and raise the awareness of the residents of Kythira Island about preventing fires, strengthening security and avoiding disasters. It started in April 2019 and concluded in October 2021.

First, the scientists worked to understand and analyze the fire problem and the conditions (e.g., fuels, topography, weather) on the island, collecting and using data from various sources (fire statistics, local newspaper archives, weather data, published reports etc.). Through these, they identified the conditions (place and time) associated with very high fire hazard. Next, fuel situations on the island were identified through a field campaign, were assigned to fuel models and were mapped through manual interpretation/digitization, in a GIS environment, developing a forest fuel map for the island for the first time. The map was then used in fire spread simulations with a fire spread simulator (G-FMIS) to predict potential fire spread. An initial simulation of the spread of the 4 August 2017 fire, comparing predictions to the real evolution with good results, ensured confidence on the predictions of the system. Further simulations under plausible adverse fire weather scenarios highlighted the damage potential and risk to homes and infrastructures posed by wildfires that may occur in specific areas of the island.



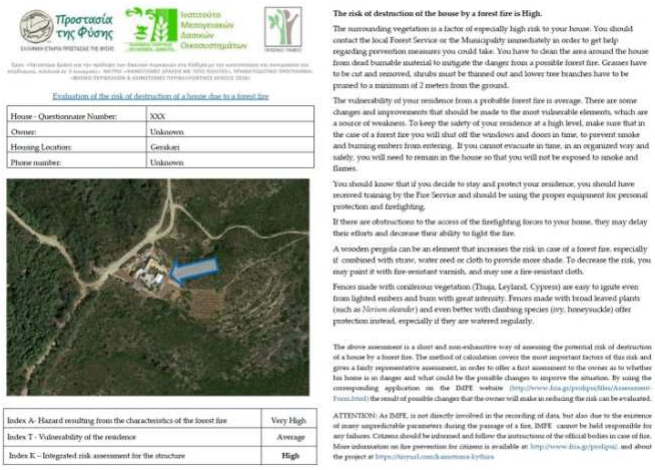
Workshops with students at the school and citizens in local places.
Author: Gavriil Xanthopoulos
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Smart fire prevention solutions with the local population are necessary in small islands and other remote places in Greece.

The scientific analysis helped to illustrate the need to be prepared for difficult fire behavior conditions that could occur without adequate firefighting support at the early stages of the fire, in a series of workshops that were tailored to specific audiences (students, farmers, tourists, tourism professionals, officers of the authorities, population at large). Both the importance of preventing fire starts and the need to improve the safety of homes became evident to all participants. This increased involvement in prevention actions, including participation in various activities, such as forest fuel management at selected locations, reforestation efforts, and contribution to volunteer groups that helped with the evaluation of the risk of destruction of nearly all the buildings (N=610) in three settlements. After training, the volunteers visited each structure and filled a form about the factors affecting its risk in case it is exposed to a fire (location, access, surrounding vegetation, building characteristics, availability of fire protection infrastructure, etc.). Using these forms and additional information (Google Earth, on-site visits), the fire experts assessed the risk to each structure and prepared a form, explaining the risk and suggesting pre-fire measures and response in case of fire, that the volunteers distributed to the owners. Furthermore, they mapped the structures and combined

Forest fire prevention involving citizens on a remote island in Greece.

Both the importance of preventing fire starts and the need to improve the safety of homes became evident to all workshop participants. This increased involvement in prevention actions.



The risk of destruction of the house by a forest fire is High.

The surrounding vegetation is a factor of especially high risk to your house. You should contact the local Forest Service or the Municipality immediately in order to get help regarding prevention measures you could take. You have to clean the area around the house from dead burnable material to mitigate the danger from a possible forest fire. Grasses have to be cut and removed, shrubs must be thinned out and lower tree branches have to be pruned to a minimum of 2 meters from the ground.

Evaluation of the risk of destruction of a house due to a forest fire

House - Questionnaire Number:	XXX
Owner:	Unknown
Housing Location:	Gerakari
Phone number:	Unknown

The vulnerability of your residence from a probable forest fire is average. There are some changes and improvements that should be made to the most vulnerable elements, which are a source of weakness. To keep the safety of your residence at a high level, make sure that in the case of a forest fire you will shut off the windows and doors in time, to prevent smoke and burning embers from entering. If you cannot evacuate in time, in an organized way and safely, you will need to remain in the house so that you will not be exposed to smoke and flames.

You should know that if you decide to stay and protect your residence, you should have received training by the Fire Service and should be using the proper equipment for personal protection and firefighting.

If there are obstructions to the access of the firefighting forces to your house, they may delay their efforts and decrease their ability to fight the fire.

A wooden pergola can be an element that increases the risk in case of a forest fire, especially if combined with straw, water reed or cloth to provide more shade. To decrease the risk, you may paint it with fire-resistant varnish, and may use a fire-resistant cloth.

Fences made with coniferous vegetation (Thuja, Leyland, Cypress) are easy to ignite even from lighted embers and burn with great intensity. Fences made with broad leaved plants (such as *Nerium oleander*) and even better with climbing species (ivy, honeysuckle) offer protection instead, especially if they are watered regularly.

The above assessment is a short and non-exhaustive way of assessing the potential risk of destruction of a house by a forest fire. The method of calculation covers the most important factors of this risk and gives a fairly representative assessment, in order to offer a first assessment to the owner as to whether his house is in danger and what could be the possible changes to improve the situation. By using the corresponding application on the IMFE website (http://www.fria.gr/proliptiko/Assessment-Form.html) the result of possible changes that the owner will make in reducing the risk can be evaluated.

Index A- Hazard resulting from the characteristics of the forest fire	Very High
Index T - Vulnerability of the residence	Average
Index K – Integrated risk assessment for the structure	High

ATTENTION: As IMFE, is not directly involved in the recording of data, but also due to the existence of many unpredictable parameters during the passage of a fire, IMFE cannot be held responsible for any failures. Citizens should be informed and follow the instructions of the official bodies in case of fire. More information on fire prevention for citizens is available at: http://www.fria.gr/proliptiki/ and about the project at: https://kythnos.fria.gr/

All the scientific project results, were made available to the firefighting authorities for their operational fire management needs.

Example of a structure risk assessment form, returned to the owner, detailing the risk from fire, suggesting prevention improvements and response if it occurs.
Author: Miltiadis Athanasiou
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this mapping with mapped estimates of Safe Separation Distance (SSD) based on simulated fire behavior potential under adverse weather scenarios, to identify extreme risk hot-spots.

All the above, were made available to the firefighting authorities for their operational fire management needs.

Their response was very positive. Many articles in the mass media of Kythira and comments on social networks and in-person discussions were also positive. On the negative side, there were a few people among the local authorities who, without an obvious reason, remained indifferent about the whole effort.

/// Always Moving Forward ///

All the activities described earlier have certainly contributed towards the main objective of the project, to improve forest fire prevention in Kythira. The element of innovation was mostly in the way the technical work blended with the involvement of the local population in order to achieve better fire prevention efficiently. Community participation is sought and is a longstanding practice around the world. However, people's attitudes are very different between countries and continents and the same is true for their social structures and their natural and built environment. As a result, the examples of community involvement cannot be simply copied. The work in Kythira demonstrated that in Greece, where less than 10% of adults participate in volunteer activities, it is possible to attract and strengthen volunteerism even in remote places such as Kythira, if the people are approached properly, are helped understand the problem they need to face, and are offered knowledge and opportunities to co-create ideas, develop activities and contribute to solutions. Motivation is key to this and it was achieved by providing examples. As the other people watched the volunteer teams become organized and trained, and then visit structures in the three settlements completing forms, they became curious. Participation in the talks and the activities increased. Many owners of restaurants and coffee shops offered their space and infrastructure for free. The elementary and high-school teachers on the island also contributed enthusiastically, facilitating the work of the environmental educators of

Effective and efficient low-cost prevention involving the population, requiring, however, guidance and motivation.

The element of innovation was mostly in the way the technical work blended with the involvement of the local population in order to achieve better fire prevention efficiently.

the HSPN. The delivery of the final risk assessment forms by the volunteers to the structure owners, on a personal basis, further increased awareness and provided motivation by example.

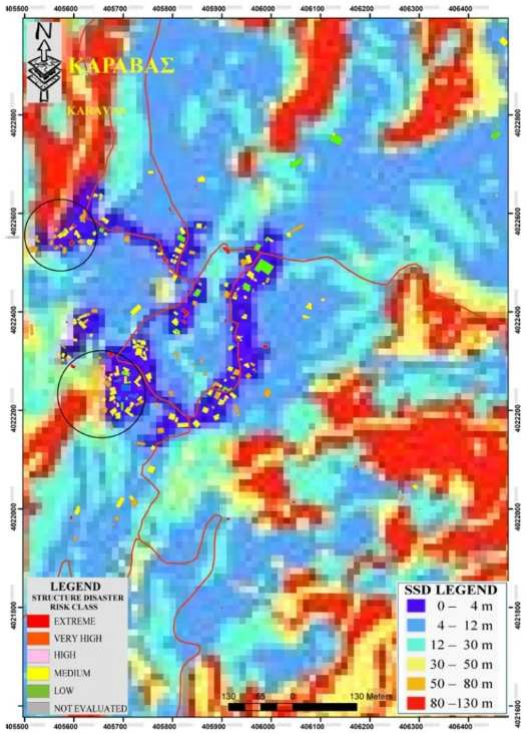
The fire prevention project in Kythira took advantage of the "window of opportunity", created by the disastrous fire of August 2017, which made the people on the island very concerned about their safety and the damage caused to the island's environment. However, they did not act spontaneously. They were happy to volunteer when the opportunity came, and devoted a significant amount of time, but there was always the need for scientific and technical guidance and cooperation from the two project partners. This became evident by the loss of momentum caused by the measures for the COVID-19 epidemic that resulted in minimization of activities throughout 2020. The activities resumed when the experts of IMFE and HSPN were able to visit the island again.

Future prevention efforts in places like Kythira, will need similar support to get off the ground. In future efforts it could come from other directions (specialized forest service employees, local authorities, NGOs, trained and motivated volunteers, etc.). The example of Kythira clearly justifies development of a well-designed country-wide fire prevention program of this type, especially for islands and other areas that face similar problems with fires.

Projects of this kind are not easy to plan and carry out over large spatial scales. It is advisable that large prevention programmes (e.g. country level) should have certain guiding axes, common approaches, and supporting materials, but should also try to consider the local characteristics and to address the people locally. This can increase both effectiveness and efficiency. A small yearly investment in fire prevention, assigning/ employing highly motivated specialized individuals, linked in a country-wide network with a small budget, to organize fire prevention activities, can make a substantial long-term contribution to reducing fire loads and damage. This cost could be less per year than three to four hours of flight time of aerial resources and the results could be tremendous.

A small yearly investment in fire prevention, assigning/employing highly motivated specialized individuals to organize fire prevention activities can make a difference and can be cost-effective.

The fire prevention project in Kythira took advantage of the "window of opportunity", created by the disastrous fire of August 2017, which made the people on the island very concerned.



Part of the map that combines home risk and SSD. High risk spots are denoted with black circles.
Author: Miltiadis Athanasiou
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Authors: Gavriil Xanthopoulos, Miltiadis Athanasiou, Konstantinos Kaoukis, Georgios Mantakas

Partners: ELGO – DIMITRA – The Hellenic Agricultural Organization

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- Type of Solution: Finance, Governance, Management
- Sector: Agroforestry, Forestry
- Good practice(s): Management alternatives, Ecosystems services, Protection against biotic and abiotic hazards

The FireFlocks Project: Precribed Silvopasture for Wildfire Risk Management

The FireFlocks project promotes forest management through extensive grazing to reduce the risk of wildfires. This case study has been implemented in the region of Catalonia (north-east Spain).



Sheep grazing a wildfire strategic area (north-east Spain)
Author: Diego Espada | © CC BY-NC-ND 4.0



Goats eating shrub fuels of a wildfire strategic area (north-east Spain)
Author: Diego Espada | © CC BY-NC-ND 4.0

/// Context ///

In Mediterranean Europe the last few decades have been characterised by dramatic land use changes. The abandonment of farmland and reduced grazing have led to an increase in wildland areas. These changes in the landscape have contributed to a more aggressive spread of large wildfires (LWF) all over Europe. A small number of wildfires are responsible for most of the burnt area. These large forest fires represent a growing risk for society, as firefighting services are unable to deal with, despite the high budgets and investments allocated. Experts state that “extinction is the answer, but not the solution”, and that the latter depends on sustainable management of forests and landscapes.

Silvopastoralism is a common practice with high benefits for society (landscape conservation, fire risk management, and the production of high quality meat and dairy products). But the presence of herds and shepherds is becoming increasingly uncommon, leading to the growth of fire prone forests. Thus, the presence of livestock in woodlands has become a shared common interest of owners, farmers, firefighters, environment rangers, and businesses willing to sell food products with an added value. All of this has motivated the project FireFlocks.

The number of participants and managed hectares has been increasing since 2016. Initially, there were 3 shepherds involved (pilot phase), in year 2021 there were 21 shepherds that formed part of the project in the province of Girona, and in 2024, thanks to the expansion in all Catalonia, there are 72 shepherds engaged in the project. Since 2016, the number of hectares that have been managed to address wildfire risk is 72.000ha.

/// Solution for a Resilient Future ///

Reducing wildfire risk

The overall objective of the project is to reduce the risk of large forest fires through prescribed grazing, meaning grazing with predefined objectives and management aimed at achieving those goals. In general, the project’s livestock farmers graze strategic fire management points (SMPs) identified by the Catalan Fire Department. These SMPs, if properly managed, limit the spread of forest fires and provide an opportunity for control operations by altering fire behavior on the day of the fire. Therefore, FireFlocks promotes targeted grazing at these strategic points, connecting, supporting, and informing farmers about existing SMPs in their area. Subsequently, a prescribed grazing plan is agreed upon with the farmers, which is the document identifying grazing objectives.

Promoting bioeconomy and ecosystem services

Due to the additional effort required by farmers for grazing in these SMPs, the project also aims to promote bioeconomy in rural areas, valorizing the livestock profession and products derived from extensive livestock farming. To achieve this, the project has created a certification for products produced from participating herds, aiming to make the end consumer more aware of the positive impact of consumption habits on reducing the risk of forest fires. The main idea is not just to sell more products, but for consumers to be able to recognize, and economically value, products derived from prescribed grazing.

In parallel, the project is working to have both products and services produced by the herds recognized and compensated as a public service. Currently, the Department of Climate Action,

Food, and Rural Agenda of the Government of Catalonia has been offering an annual subsidy since 2018 for fire prevention actions. Payment depends on two variables: managed hectares and the category of those hectares in terms of fire prevention.

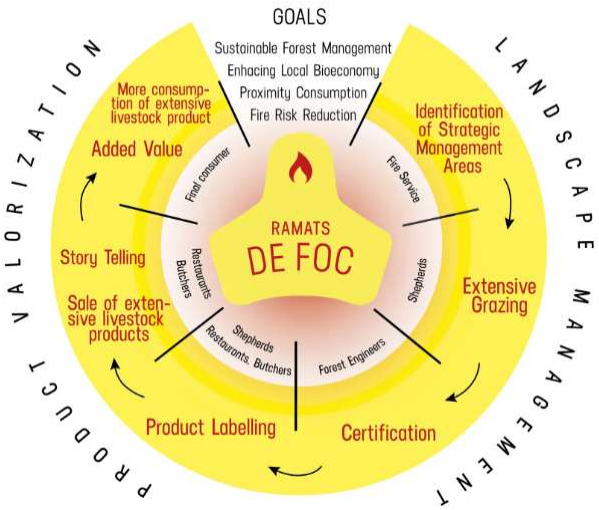
Specific lines of work

The following lines of work are being developed in order to achieve large-scale implementation of the strategy:

- Establish a solid, useful and dynamic territorial base in SMPs and other fire risk management infrastructures.
- In this territorial base, locate and analyze existing agents, offering the opportunity to learn about and join the project, identifying and stimulating new distribution channels in the case of generating agri-food products, and receiving a payment for service for managing the vegetation in the strategic areas.
- Involve the competent administrations in the governance of the project, in the fields of mapping, economic items, establishment of payment criteria for services, simplification and adaptation of the legislative and administrative bureaucracy to the reality of the sector.
- Locate and accompany the establishment of new livestock projects aimed at grazing and the management of strategic areas, increasing the current impact of the sector on the management of forest space.
- Generate social impact of the FireFlocks brand. Increase knowledge and social recognition of pastoralism and transmit the message to a large part of society through dissemination, awareness and education.
- Influence public policies that affect extensive livestock farming, specifically focused on fire risk management, for the defense of the values of human activities and ecological processes that favor the maintenance, conservation and sustainable management of the mosaic landscape.



FireFlocks logo
Author: Pau Costa Foundation | © CC BY-NC-ND 4.0



FireFlocks methodology. From landscape management to product valorization
Author: Pau Costa Foundation | © CC BY-NC-ND 4.0

/// Always Moving Forward ///

The main drivers behind the reduction in extensive livestock farming have been the low competitively of products in a global market context, the intervention of more intermediaries between the farmer and the final consumer, a lack of young people interested in working in the extensive livestock sector, and a lack of policies promoting extensive livestock farming. Hence, a challenge of the project managers is to design an ecosystem service payment scheme to economically recognize the effort of shepherds grazing wildfire strategic areas.

As indicated in the Strategic Plan for Extensive Livestock Farming in Catalonia, the subsidies should transition to service payments, establishing a formula to calculate the ecosystem benefit provided by the herds, allowing farmers to receive fair compensation. These payments should acknowledge that the work carried out by the herds, with specific objectives, is being done correctly and, therefore, warrants certification and economic compensation. All of this is done without the intention of making the operations dependent, as sometimes occurs in other lines of direct assistance. The integration of both strategies, the valorization of products and payment for the service, is possible based on the premise that these herds are included in both the primary sector, where they produce food and other products, and the tertiary sector, producing ecosystem services.

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Type of Solution: Governance Sector: Forestry
Good practice(s): Financing, Community Engagement, Protection against biotic and abiotic hazards

Enhancing the resilience of forest landscapes: a pilot experience through the active participation of the Oued Zeen village local community in Tunisia

Preserving and managing forest landscapes through local communities: sustainable exploitation of Non-Wood Forest Products resources.



The landscape of north-west Tunisia contributes to the socioeconomic development of the local population | Author: Sondes Fkiri | © Sondes Fkiri



Involvement of the local community in cleaning and planting carob trees in degraded forests in the Siliana region, northwestern Tunisia | Author: Sondes Fkiri | © Sondes Fkiri

/// Context ///

Forest land in Tunisia is primarily owned by the state. The main forest regime is the State's private domain, which covers a total of 925,736 hectares, and private lands subject to the forest regime, which cover a total of 54,492 hectares. The latter is divided into afforestation contracts (9,524 hectares), dune fixation areas (21,229 hectares), and soil protection areas (23,739 hectares) (ONAGRI 2021).

Due to the inadequacy of current legislative texts regarding access to non-wood forest products (NWFP) resources for the benefit of households living in forested areas, a special exemption from the Ministry of Agriculture has been established and tested. It aims to enable the implementation of co-management agreements as part of a pilot experiment in particularly vulnerable forest areas through the World Bank-funded Integrated Landscape Management in Lagging Regions Project, with the institution acting as the financial sponsor of the project.

This exemption allows local communities to exploit forest products, such as rosemary, myrtle, pine seeds, mushrooms, and carob pods, free of charge. The administration has authorized the exploitation of these resources in Tunisia for a period of 3 years as part of the implementation of the co-management agreement with the Agricultural Development Group (GDA). Local communities carry out work to prevent fires and develop forests in exchange for the authorization to exploit these resources for a period of 3 years. As part of the co-management agreement with the GDA, the local population monitors these forest areas, particularly to prevent poaching and protect against fires.

/// Solution for a Resilient Future ///

The North-West and Central-West Tunisian regions have rural landscapes that feature mixed farming systems. These systems combine crops, agroforestry, forests, tree plantations, and pastures. Rural households rely heavily on natural resources, particularly forests and pastures, which provide subsistence, employment, and cash income. Unfortunately, forests are currently facing significant threats. Fires, illegal logging, deforestation, and rapid urban development are all current threats to forest existence. The degradation of forest areas, impoverishment of local communities, and fragility of ecosystems and biodiversity are indirect threats resulting from insufficient resources and poor governance.

To address this issue, a pilot experiment was conducted to promote **co-management of forest resources**. The experiment was carried out on 17 forest sites, each associated with an agricultural development group (GDA). Here we present the result found in Oued Zeen village, which has a surface area of 1,985 m2, and is

characterized by extensive forests of zeen oak (Quercus canariensis), from which the village takes its name. This species represents a national heritage to be preserved, and the co-management agreement could be a viable solution to promote its protection and regeneration.

The method used to evaluate the effectiveness of this solution relies primarily on a combination of data regarding the frequency of fires and the extent of the areas affected, categorised into three levels: positive, negative, or stable. The parameter used to assess the economic impact on the population is the number of working days created to exploit non-wood forest products.

This is a co-management approach with considerable potential, the success of which depends on both contracting parties meeting their commitments, and on a minimum level of financial resources being made available.

Due to the implementation of the co-management agreement between the authorities (General Forestry Department) and local communities (presented by the GDA), the fire impact assessment showed a relatively stable trend and negligible damage during the convention period (2019-2021). The local population contributed 4,920 working days to forest management, including 1,800 days of forest cleaning and 100 days of guarding against poaching. In return, 847 tonnes of myrtle were distilled over three years.

The adoption of this management model by the local population stems from the increased trust between certain GDAs and their members, and between the GDAs and the forestry administration.



Fires and drought threaten Tunisia's forest landscape Devastated forests, ashen landscapes, calcinated trees: a new landscape dominates the North-Western region
Author: Sondes Fkir | © Sondes Fkiri



The village of Oued zeen characterized by its wide Quercus canariensis forests: A national heritage to be preserved | Author: www.radiokef.tn | © www.radiokef.tn

/// Always Moving Forward ///

In the future, adopting a new co-management vision for forest resources, based on equitable access and active involvement of local populations, will diversify income sources for forest households and strengthen collective efforts towards forest preservation and fire prevention.

The aim of this agreement is to create a sustainable framework that balances the economic interests of the local population with the well-being of the ecosystem, while also promoting its resilience to future climate challenges.

Local populations will be essential collaborators, promoting exchanges and participating in co-managing projects that meet mutual needs.

The state should involve the community in forest heritage management by encouraging their participation in decision-making and project planning. This will reinforce their sense of responsibility and ownership. Participatory governance mechanisms can be put in place to guarantee equitable representation and ensure that everyone's voice is heard. Additionally, there is a need to invest in building the skills of local people. This includes training in innovative preservation techniques, early fire detection, and sustainable management of natural resources.

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Authors: Sondes Fkiri; Kachouri Habib; Samir Ghannem; Boutheina Stiti; Issam Touhami; Sonia Mbarki; Ali Khorchani; Samir Thahri; Jeanne Chiche; Mohamed Tahar Elaieb | **Partners:** INRGREF – National Institute of Rural engineering research, Water and Forests

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Panasqueira Aggregated Forest Area pilot project

Aggregate forest management on a smallholding located in the municipality of Águeda, Portugal.

/// Context ///

The small size of forest ownership in the North and Center of Portugal is the source of the technical difficulties to comply with the legislation and good practices promoted by forest certification and responsible for high operating costs necessary to manage the forest. These facts, added to the long period of return on forest investments, low profitability rates of the business and high risks (fires, pests and diseases) have greatly contributed to the demotivation of the small family-owned forestland, leading to the gradual abandonment.

> **Finding organizational models of property management on a larger scale is perhaps the main challenge for small forest owners.**

Finding organizational models of property management on a larger scale is perhaps the main challenge of small forest owners, since allows to minimize the identified constraints.

This challenge resulted in the first pilot project called Aggregated Forest Area (AFA) of Panasqueira, located in Castanheira do Vouga, municipality of Águeda. The pilot consisted in joining the management of 15 properties (total area of 12 hectares) based on a formal agreement signed by all owners, establishing rules of operation, common commitments and guidelines to implement the management and investment plan.

> **Innovation in organization models for the management of small sized forest property - Aggregated Forest Management.**

The main benefits achieved with this management model were:

- Motivation of owners, by the expectation of improved profitability as a result of efficiency and operational management gains on a larger scale and also by improving the productivity of stands;
- Reduction of investment risk, mainly by improving fire resilience, but also by monitoring health problems;
- Environmental enhancement of forest areas, by safeguarding and commitment to relevant environmental values, forest diversification and enhancement of ecosystem services;
- Adherence to PEFC Regional certification as a result of the work developed, a fundamental tool for the valuation of products, services, and both national and international recognition.



Figure 1. Property structure of AFA project under study, showing the size of the plots relative to the football field. | Author: Luis Sarabando (Associação Florestal do Baixo Vouga) | © Educational use, non-commercial.

This model of organization between adjoining small forest owners is available to all, since it is practical, expeditious, unbureaucratic and mainly, only dependent on decisions of the owners themselves.

> **This model of organization between adjoining small forest owners is available to all, since it is practical, expeditious, unbureaucratic and, mainly, only dependent on decisions of the owners.**

/// Solution for a Resilient Future ///

Private ownership in the northern and central regions of Portugal is characterized by its small size and dispersion (Figures 3 and 4). For example, the structure of the property adhering to the PEFC Regional Certification System in the Aveiro region, has an average of 10 properties per owner and shows that 70% of the properties have an individual area of less than one hectare.

Innovation in organization models for the management of small sized forest property - Aggregated Forest Management.

The small size of the property leads to technical difficulties to comply with the legislation and good practices promoted by forest certification and, is also, responsible for high operating costs required to manage the forest. Taking into account the long return period of forest investments, the low profitability rates of the business and also the high risks of the activity (fires and pests and diseases) the demotivation of the small family-owned forestland it is evident and contributes to the gradual abandonment.

In addition, the social and political context of recent decades (continued of the rural exodus, removal of the owners and the lack of consistent forest policy reforms) has not allowed us to foresee structural solutions that contribute to change the current situation.

Associação Florestal do Baixo Vouga (AFBV) is an organization of forest owners working in the Aveiro region since 2000. With the aim of finding solutions to the above scenario, an integrated package of planning services, certification, forest management services and commercial mediation has been developed, allowing AFBV to currently represent 1700 associates, with 22,000 ha of forest in Aveiro, and manage a regional PEFC certification system.

With the accumulated experience and territorial representativeness achieved, in 2018, AFBV involved a group of owners in the reflection and search for organizational management models, seeking to overcome the constraints of the small size of the property and the socio-economic context. This led to two main conclusions:

AFBV involved a group of owners in the reflection and search for organizational management models, seeking to overcome the constraints of the small size of the property.



Figure 2. Real image of Panasqueira's AFA. The lines show the division of initial properties.
Author: Luis Sarabando (Associação Florestal do Baixo Vouga)
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This pilot consisted in joining the management of 15 properties (total area of 12 hectares) based on a formal agreement signed by all owners, establishing the rules of operation.

- Increasing the scale of the management plots is perhaps the main challenge for small forest owners, as it will allow to minimize many of the identified constraints;
- The organizational management models to be adopted should be practical, quick, non-bureaucratic and mainly dependent on the decisions of the owners themselves.

This challenge resulted in a first pilot project called the Aggregated Forest Area (AFA) of Panasqueira, located in Castanheira do Vouga, municipality of Águeda. This pilot project consisted in joining the management of 15 properties (total area of 12 hectares) based on a formal agreement signed by all the owners, establishing the rules of operation as well as the common commitments and guidelines for the implementation of the management and investment plan.

In summary, the aim was to enable the management of 15 small individual properties, to date almost entirely abandoned, through the exemplary and certified management of 1 property with 12 hectares. In this model, similar to a "condominium management", each owner holds a share equivalent to the percentage of his area over the total area of the project. All investments and the eventual distribution of income are determined according to this ratio, regardless of the use and productivity of each owner's original area.

The objective was to make possible the management of 15 small individual properties, to date almost entirely abandoned, in the exemplary and certified management of 1 property with 12 hectares.



Figure 3. Characteristic landscape of the North and Central regions of Portugal showing the small size of the properties.
Author: Luis Sarabando (Associação Florestal do Baixo Vouga)
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Professional management is ensured by AFBV's technical services, regardless of the type of owner (present/absent, knowledgeable/uninformed) and owners remain involved and motivated in monitoring management.

The main benefits achieved with this management model were:

- Motivation of owners, expecting improved profitability as a result of efficiency and operational management gains on a larger scale, as well as improving the productivity of stands;
- Reduction of investment risk, mainly by improving fire resilience, but also by monitoring health problems;
- Environmental enhancement of forest areas, by safeguarding and commitment to relevant environmental values, forest diversification and enhancement of ecosystem services;
- Adherence to PEFC Regional certification as a result of the work developed, a fundamental tool for the valuation of products and services, and national and international recognition.

Since 2018, AFBV has continued to focus on exploring AFA project development opportunities and currently has 7 projects in the field (average of 2 projects per year, excluding the COVID 19 pandemic period).

/// Always Moving Forward ///

The development of Aggregated Forest Area projects brought to the collective discussion and/or practical work several challenges on structural issues, that should be initially considered when implementing a similar project:

- Construction of a draft contract/ agreement, a very sensitive matter to obtain consensus between interested owners, clearly establishing the rules in the organizational and functional scope (rights, duties, guarantees and penalties of owners). Drafting an agreement is a very challenging task regarding the possible presence of so many different type of interests of the owners (Owner investor/executor, owner with interest but absent, owner without interest, owner without decision-making ability such as inheritances cases).
- Identification of owners. Most of the Portuguese territory does not have a geometric registry of the property. Consequently, the first major challenge is the identification of all the owners of the project area and their individual awareness for it, knowing that most of them it is not living in the proximity of the project area. Achieving the trust factor is vital, and it is crucial the recognition of the work of Associação Florestal do Baixo Vouga in the region for sucessful owner engagement.



Figure 4. Digital map of the property structure adhering to the PEFC Regional Certification System in the Aveiro Region.
Author: Luis Sarabando (Associação Florestal do Baixo Vouga)
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Successfully implementing Aggregate Management models by predicting and preparating simple answers to identified issues.

- Mapping survey of the structure of the property. This process also requires a large amount of dedication and sensitivity on the contact with many historical disputes between adjoining small forest owners and that must be managed, in order to not interfere in the decision of joining into the project.

- Ensure legal support capacity for the cases where property titles are not properly updated. Ensure legal support capacity step is fundamental to the legitimacy of the agreement signed by the owners and is a sensitive point because it can be time-consuming (for example, undivided inheritance decisions) or have significant costs.
- Ensure technical consensus on the measures and actions to be included in the project, as well as on the investment plan and the weighting of risks and potential for loss and their distribution by the owners involved.
- Ensure financing capacity for the owners who doesn't have investment capacity.
- Identify possible sources of public or private grants for the actions plan in the project, as an important motivational factor for the adhesion of the owners.
- Ensure technical support capacity for the operationalization and monitoring of forest work and following-up the development of the project.

As a conclusion, in future terms, it is essential that the forestry policy of the sector recognize this type of models and local dynamics, creating a framework of robust legal and financial tools and facilitating the implementation of these projects.

This is a very challenging task regarding so many different type of interests of the owners.

in future terms, it is essential that the forestry policy of the sector recognize this type of models and local dynamics, creating a framework of robust legal and financial tools.

To make this possible, it is essential that organizations have technical, legal and financial capacity to promote these models, facing all the difficulties of the process described above.

The success of the implementation of these models depends on the anticipation of answers to most issues already identified. It also depends on technical capacity for active presence and permanent contact with the owners and to accelerate the treatment of all subjects, avoiding demotivation or slowing down the process.

The trust factor is vital, and it is crucial the recognition of the work of AFBV.



Ownership structure of the AFA pilot project of Panasqueira, in the municipality of Águeda.
Author: Luis Sarabando (Associação Florestal do Baixo Vouga)
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Further information

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Acknowledgment / Contribution

Associação Florestal do Baixo Vouga; PEFC Portugal.

Authors: Luis Sarabando; Associação Florestal do Baixo Vouga. Raquel Martinho; PEFC Portugal.

Partners: ISA – Instituto Superior De Agronomia

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Optimizing forest management in large areas with multiple management bodies

Towards forest sustainability: the benefits of optimization and large-scale implementation in forest management. A case study in the Boticas Communal Areas (Northern Portugal).

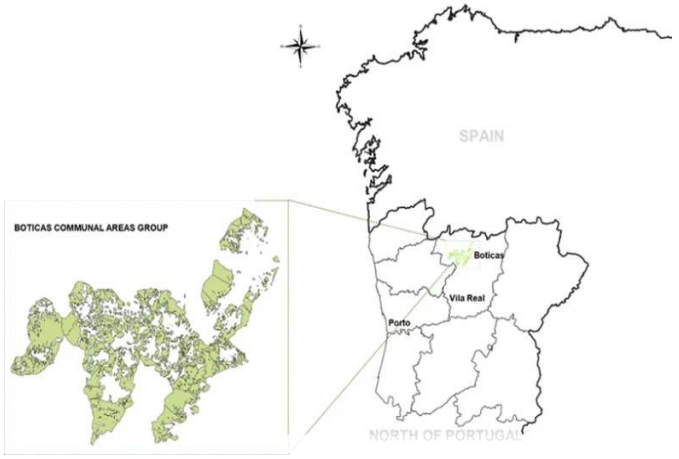


Figure 1. Geographical location of the study area, in the North part of Portugal, county of Vila Real, municipality of Boticas.
Author: Margarida Cabral | © Educational use, non-commercial.



Figure 2. Stand of Pinus pinaster in the study area.
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/// Context ///

Effective forest management can benefit from optimization-based planning, especially in complex scenarios involving large areas and multiple managers. This study evaluates governance models and the effectiveness of optimization models as tools to support forest management across large areas managed by multiple bodies. The focus is on maritime pine (Pinus pinaster Ait.) areas in 22 commonlands in Portugal over a 30-year planning period. Two governance models are considered:

- Individual model (I) – each communal area is managed independently
- Global model (G) – brings together areas and their respective owners for collective management

A baseline management model (FMP-B) is set as a proxy for an empirical model, contrasting with the two governance models: individual (FMP-I) and global (FMP-G). In FMP-I and FMP-G models, thinning and clear-cutting activities were strategized to optimize revenues over each five-year span, while adhering to silvicultural, operational, and sustainability limitations, setting conditions on the age structure of the forest namely a minimum average ending age and balanced area distribution among age classes in the last year of the planning horizon.

FMP-I and FMP-G models show lower volume removal, yet offer a more balanced wood supply distribution over time. Although the FMP-G model's integrated approach reduces 8.6% in total volume removal compared to FMP-I, it establishes well-diversified stands in terms of age classe by the end of the planning period.

/// Solution for a Resilient Future ///

The success of sustainable forest management relies on strategic planning and decision-making, supported by scientifically-based methods such as forest growth simulators and optimization models, as well as appropriate governance that ensures stakeholder interests and sustainable principles. This project aimed to address the challenges inherent in managing large areas, overseen by multiple management bodies.

The study was conducted in the Boticas Communal Areas Group ("AD-Baldios do Concelho de Boticas"). It includes 22 common lands and covers around 5000 ha of maritime pine forests (Figure 1).

The study uses optimization tools to plan harvesting and thinning activities over a 30-year planning horizon. The aim is to maximize harvest volume while respecting sustainability, silvicultural, operational, and environmental constraints. Data is taken from the ModisPinaster growth model, which includes thinning between 12 and 27 years and stand densities between 30% to 60%. Three forest management plans (FMP) were considered.

Model FMP-B serves as a proxy for an empirical management plan, where the key constraints are:

- Clear-cutting in the first period for stands over 70 years old.
- No clearcutting in stands less than 35 years old.
- A minimum of 5 years between thinning and clear-cutting in each stand.
- The cutting area of adjacent stands bounded by 10 ha over any two years period (according to Portuguese regulation).

The goal is to determine where and when clear-cutting should be undertaken to maximize the volume of wood harvested over the planning horizon.

In addition to the base model, two more restrictive optimization models are considered, each tailored to the specific governance model:

- FMP-I (Independent Management Model): manages each common land independently.
- FMP-G (Global Joint Management Model): groups areas and their owner bodies for collective management.

  Both models aim for sustainable management with a balanced age-class structure, adhering to constraints on harvested areas and balancing volume revenues.

They ensure consistent income for each communal area, align with community interests, and adjust plans for stand stability to wind damage.

Table 1 shows the volume removed and the final average stand age for the three models. Figure 4 depicts age class distribution in the last year of the planning horizon.

Model	Volume (m³)	Average age (yr)
FMP-B	1 901 081.9	10.1
FMP-I	1 766 397.0	20.4
FMP-G	1 626 701.4	21.0

Table 1. Optimal solutions in terms of total volume removed (m³) and average age (yr) at the end of the planning period.

In the optimal solution of the baseline model, FMP-B, 89% of the clear-cutting area is cut in the last two 5-year periods leading to an average final age particularly low (Table 1), compromising future management of the study area. In addition, the distribution of area by age class is unbalanced with a large a large area in the juvenile stage of development. A similar trend is noticed with FMP-I.

Although the total volume of timber harvested over the planning horizon is lower with the FMP-G model (1643956.8 m³), this model produces results that are most consistent with the principles of sustainable forest management.

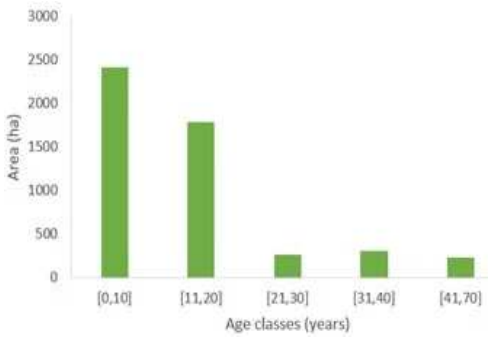


Figure 3. Maritime pine forest age in 2021 with 84% of stands up to 20 years old due to frequent wildfires and subsequent natural regeneration.
Author: Margarida Cabral | © Educational use, non-commercial.

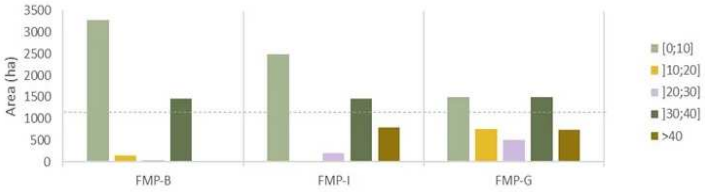


Figure 4. Area distribution by age class in the final period using FMP-B, FMP-I, and FMP-G models.
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/// Always Moving Forward ///

The study underscores governance and optimization's roles in shaping effective forest management plans for medium to long-term sustainability in large forest areas. Restrictions in the MFP-I and MFP-G models are designed to achieve a balanced revenue supply, leading to reduced wood removal compared to the baseline model, which fails to provide such equilibrium over the planning period. Model restrictions in MFP-I and MFP-G reduce total wood removal at the planning period, in contrast to a baseline model, to ensure a balanced revenue supply over time. However, only the MFP-G achieves superior sustainability outcomes, highlighting effective resource sustainability is best achieved through global management. However, these restrictions alone may not guarantee resource sustainability, especially with independent management.

The FMP-G model comprehensively addresses the three pillars of sustainability – environmental, economic and social. Environmental considerations in the model include forest stability and assurance of a more balanced age class distribution in the area. Achieving a balanced volume of income over the planning horizon, tailored to the preferences of local entities, with guaranteed income in each 5-year period, directly addresses economic value and social preferences.

Collaborative forest management involving multiple stakeholders has proven to be fundamental for long-term sustainability. The proposed model is adaptable, and advisable for diverse forest areas, including communal or privately owned ones. Future iterations should consider dynamic biotic and abiotic factors for adaptive forest strategies, exploring forests' multifaceted roles like resin production and carbon sequestration.

Further information

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Type of solution: Governance Sector: Agroforestry, Forestry
Good practice(s): Community engagement

Associazione Fondiaria Valli delle Sorgenti

A governance solution for improving the resilience of abandoned forests in Lombardy region.



Impacts of the fires that affected the forests of Luvinate municipality a few years ago.
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Broadleaves and conifers present in the area.
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/// Context ///

Forest management abandonment might expose natural areas, and people, to more severe risks associated with the increasing frequency of extreme events, e.g., large wildfires, droughts, floodings, windstorms, etc. (Rodríguez Fernández-Blanco et al. 2022). Land fragmentation, accompanied by gradual abandonment of rural and mountainous territory, impose the need to identify functional tools to encourage active and responsible forest management.

Among the proposed solutions, at Italian level, the Piedmont and Lombardy regions have recognized and promoted, through specific regional laws, an innovative type of association forms: the “Land Association” (in Italian Associazioni fondiarie – ASFO). The main idea behind land associations is the explicit purpose of bringing together the lands of individual members (public and private) under one common management, with the possibility for the land associations to be assigned by municipalities uncultivated or abandoned lands.

Among the land associations created in the last years thanks to regional laws, “ASFO Valli delle Sorgenti” is an excellent example. In fact, thanks to this association, public entities, such as the municipality of Luvinate (a small town near Varese, in Lombardy), and a regional park, and 40 other small private forest owners cooperate to manage 161 hectares of forest, which are highly susceptible to fires and flooding.

/// Solution for a Resilient Future ///

The “Land association”(ASFO) represents an innovative type of association, promoted by the Lombardy and Piedmont regions, created specifically to curb the phenomenon of land fragmentation and land abandonment in rural areas (Beltramo et al., 2018). These associations should be based on a single management plan for all associated ownerships, in which the best technical and economic solutions for specific agricultural and forestry production objectives must be identified, guaranteeing the preservation of the environment and landscape. Within the association, property rights are not altered and individual lands can be managed (according to the plan, agreed upon) directly by the owners or they can be entrusted to individual members or third parties (through leases). According to regional laws, municipalities can also assign abandoned and silenced land to the land associations (Pettenella and Loreggian, 2023).

One of the land associations created as a result of the lombardy regional law and which has more innovative features is the Land Association “Valli delle Sorgenti”, the origin of which starts from a fire that had affected dozens of hectares of forest not managed or abandoned. In fact, in 2017, a vast wildfire affected the forests of the mountain “Campo dei Fiori”, in the alpine area of Lombardy region, burning dozens of hectares and also threatening the small municipality of Luvinate. Favored by these fires, in subsequent years, floods with debris flows and windstorms still affected these forests, with strong social and environment impacts. After these calamitous events, rapid and effective management was strongly necessary for the restoration of damaged forest areas and prevention of other possible natural disasters. However, the areas affected by the fires and subsequent natural disasters (floods) were owned by many small private landowners and public landowners (a municipality

and a regional park), so it was very difficult to implement a common and effective management and planning. In 2021, thanks to the efforts of the mayor of the municipality of Luvinate, the Land Association “Valli delle Sorgenti” was created with the clear objective of shared management of the members’ forest, through a common multi-year management plan.

Since 2021, the Land association “Valli delle Sorgenti” has achieved really important results. To date, the association has more than 40 members, both public (municipality of Luvinate and the regional park “Campo dei Fiori”) and small private owners for a shared management of 161 hectares (36% public and 64% private), representing 70% of the areas affected by natural disasters from 2017 onwards. Through the activities of the association, 10 different forestry operations have been activated, thanks mainly to public funds from regional funds and European projects, such as the LIFE Climate Positive Project.



Forest management implemented thanks to the activities of the associations.
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Involvement of local communities in the actives.
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/// Always Moving Forward ///

To date, the main incomes of the Land Association “Valli delle Sorgenti” derive from public funds provided for the planning and for some specific forestry operations. The next challenge for the association is to diversify revenues by also attracting private funds for maintaining and enhancing ecosystem services provided by the forest area. For this reason, in 2023 the association began the process to achieve forest management certification according to the FSC standard. In addition to forest management certification, the association is verifying and monitoring the impacts of forest management on ecosystem services, according to FSC Ecosystem Services Procedure (FSC-PRO-30-006). In fact, this procedure aims to establish requirements for FSC-certified forest managers to credibly demonstrate the impact of their activities on ecosystem services, as well as provides tools for forest managers to access ecosystem services markets and/or other benefits. Once the area and ecosystem services have been certified, the land association should improve its marketing skills to attract investors, as well as analyze fiscal issues within members to properly manage private and public revenues.

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Acknowledgment / Contribution

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Authors: Nicola Andrighetto – Etifor | **Partners:** ETIFOR – Valuing Nature

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Type of solution: Governance, Management Sector: Agriculture

Good practice(s): Management alternatives, Community engagement

The Land Stewardship Program: a case study enhancing resilience in Menorca island

A governance solution promoted by GOB Menorca to create a resilient, sustainable, and inclusive agricultural system that benefits farmers, consumers, and the environment.



Mosaic landscape in Menorca.
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Alliance for Mediterranean Nature and Culture (AMNC).
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/// Context ///

Menorca, an island in the western Mediterranean Sea, has held Biosphere Reserve status since 1993. Its countryside features a diverse mosaic of land uses preserved over millennia, crucial for ecological conservation. This mosaic landscape, comprising cultivated fields and wild vegetation bordered by extensive dry-stone walls, supports rich biodiversity largely shaped by the sustainable and traditional practices of local communities.

Despite these environmental benefits, Menorca's farmers confront significant challenges—environmental, economic, and cultural. These include land degradation, water scarcity, loss of biodiversity and agrobiodiversity, low farming prestige, poor working conditions, and limited opportunities for young people. Additionally, maintaining long-term social and environmental benefits requires ensuring that businesses remain economically viable. In response, the Balearic Group of Ornithology and Defense of Nature (GOB) has initiated the Land Stewardship Scheme. This program seeks to engage all stakeholders—farm owners, managers, society, consumers, and policymakers—in environmental preservation efforts. Through Land Stewardship Agreements, farmers commit to sustainable management practices, while GOB offers support and recognition. The ultimate objective is to ensure that environmentally sustainable farming practices are socially equitable and economically viable, securing the long-term viability of agriculture on the island.

/// Solution for a Resilient Future ///

Menorca faces pressing challenges that threaten its landscapes and biodiversity. Economic pressures have led to the abandonment of traditional farming practices on some farms, while others increasingly pursue intensive methods for short-term economic gain. These shifts pose significant cultural, socio-economic, and environmental challenges to the island's ecosystem. In response, the Balearic Group of Ornithology and Defense of Nature (GOB) launched the Land Stewardship Program. This innovative initiative aims to support farms committed to environmental stewardship, ensuring their economic viability and sustainability. By promoting agricultural management systems that integrate economic profitability with environmental conservation, the program seeks to safeguard Menorca's natural heritage for future generations.

The Land Stewardship Program operates through voluntary agreements between GOB Menorca and participating farms. These agreements are customized to each farm's specific activities and biodiversity context. Farms commit to implementing a set of mandatory measures for natural resource management and can choose additional sustainable practices tailored to their needs and preferences.

Key mandatory practices include minimizing herbicide and pesticide use on their farms, preserving areas of wild vegetation that serve as habitats for diverse wildlife and maintaining dry-stone walls. Optional practices encompass cultivating leguminous and traditional crop varieties, using organic fertilizers, practicing crop rotation, and managing livestock in semi-free regimes with native breeds.

GOB Menorca plays a pivotal role in supporting participating farms. It actively promotes their products to local and broader markets, fostering consumer awareness and demand for locally produced, sustainably sourced food. Through initiatives such as product tastings and farm visits, participation in fairs and markets, and facilitating direct sales channels, it enhances market access for farmers. In order to support farmers to effectively transition to sustainable or regenerative practices, GOB also helps farmers in different direct actions: restoring rainwater harvesting systems, installing nesting boxes, and restoring soil fertility, among others. In addition, it engages in outreach efforts, volunteer programs, and environmental education campaigns in schools. These activities cultivate a culture of environmental stewardship and promote consumer behavior shifts towards choosing local and sustainable products. Regular training days and workshops further empower farmers with knowledge and skills in sustainable management practices.

The land management practices encouraged by the Land Stewardship Program contribute significantly to climate change mitigation. These practices enhance carbon storage in agricultural soils, mitigate wildfire risks through controlled grazing, and reduce reliance on fossil fuel-derived chemicals. Moreover, Menorca's mosaic landscape supports biodiversity by maintaining wildlife corridors, diverse habitats, and resilient food chains involving plants, invertebrates, and birds.

Through these concerted efforts, GOB Menorca and its Land Stewardship Program are pivotal in preserving Menorca's natural landscapes, promoting sustainable agriculture, and ensuring a harmonious balance between economic prosperity and environmental conservation.



Custòdia Agrària agreement with Binibò farm.
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Training activities.
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/// Always Moving Forward ///

The program is constantly evolving through a process of reflexive learning. GOB Menorca regularly reviews its work with participating farms, incorporating feedback and engaging in research and networking to foster innovation and development. This approach ensures the program's ongoing effectiveness in addressing critical environmental challenges such as land degradation, erosion, countryside homogenization, water scarcity, and biodiversity loss.

Currently, 39 farms are part of the Custòdia Agrària network. In the future, reaching and including more farmers in the land management program could help GOB Menorca further strengthen the farming community by enhancing the sharing of knowledge, resources, and support. Expanding participation will consolidate the excellent results achieved so far, amplifying the positive impact on the environment and the local economy. Increased farmer involvement will also contribute to preserving traditional farming practices and local varieties of crops and livestock, integral elements of Menorca's cultural heritage.

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Community-based management of natural resources for sustainable development in Morocco: a case study

Agdals of the High Atlas: sustaining tradition and balancing conservation and livelihoods in rural Morocco.



Community-based grazing in the High Atlas.
Author: Inanc Tekguç | © Educational use, non-commercial.

Alliance for Mediterranean Nature and Culture (AMNC).
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/// Context ///

Across the Mediterranean region, various forms of community-based management of natural resources have developed into traditional and diverse land-use systems. These systems have significantly strengthened local food systems and enhanced their resilience. One enduring example of such an institution is the “pastoral agdal”, a socio-ecological landscape and knowledge system. Found in North Africa, particularly in the High Atlas Mountains of Morocco, the agdal system boasts a 4000-year pastoral tradition.

The main objective of pastoral agdals is to act as fodder reservoirs during critical periods of need, when fodder availability is scarce or severely affected by severe weather events. Their associated management strategies have also historically fostered the conservation of biodiversity and the regeneration of rangeland and forest resources.

A key feature of this type of agdals is the timing of the opening and closing dates of the pasture. This practice ensures that vegetation can complete its full reproductive cycle before grazing begins. During crucial moments in the plant cycle, such as spring, herding is prohibited, guaranteeing high plant and biomass growth, along with flowering, pollination, and seed production. This sustainable approach supports a diverse range of animals, including goats, sheep, cows, horses, and even dromedaries, ensuring the health and productivity of the ecosystem.

/// Solution for a Resilient Future ///

In rural Morocco, Agdals are integral to the sustainability of High Atlas communities, enabling them to maintain their herds despite challenging climatic conditions. By combining aspects of production and conservation, they help preserve the ecological balance and sustain the livelihoods of pastoralist communities.

The agdal system is a traditional method of community-based natural resource management that regulates access to agrosilvopastoral resources, often between different Amazigh tribes and their fractions. Rooted in customary practices, it is governed by collective land management through household assemblies (jmâa), communally selected guardians (aêssass), and traditional laws (laôrf). These institutions collaboratively decide the opening and closing times for the agdals, adjusting them annually based on ecological needs and community agreements. Additionally, they ensure compliance with mutually agreed-upon standards, imposing sanctions on those who infringe upon them (Plieninger et al., 2022).

The primary function of agdals is to seasonally prohibit access to these resources to allow for their recovery during sensitive plant-growth periods. This system is crucial in regions facing natural resource scarcity, such as lack of grazing grounds and water shortages. The ecological benefits they provide are also significant. Studies, such as those by the Alliance for Mediterranean Nature and Culture (AMNC) in the Igourdane agdal, have shown that these systems support significant biodiversity and vegetation recovery. Compared to areas without traditional management, agdals exhibit greater plant species diversity and healthier vegetation cover. The seasonal grazing restrictions allow plants to complete their reproductive cycles, leading to robust

seed production and plant regeneration. This practice supports the resilience and sustainability of pastoral ecosystems.

From an economic perspective, agdals help maintain livestock health and productivity by ensuring the availability of fresh fodder during critical periods, such as increasingly hot and dry summers. This stabilizes the economic base of pastoralist communities who depend on livestock for their livelihoods. Additionally, agdals promote social justice by ensuring that all community members have equal access to pasturelands. The collective management system facilitates shared benefits and responsibilities, fostering a sense of community and fairness. Grounded in local customs and traditions, agdals effectively reduce conflicts over resource use. The community-driven decision-making process and enforcement of rules by local authorities help manage disputes and promote harmony (Dominguez, 2019).

In addition to their environmental and socio-economic functions, agdals play a crucial role in preserving cultural practices and knowledge. They are deeply embedded in the social fabric, upholding traditional rituals and collective management methods that reinforce community identity and cohesion. Ultimately, agdals represent a vital socio-ecological system in Morocco, merging traditional Amazigh wisdom with communal management to promote sustainable natural resource use (Auclair et al., 2011).



Sheeps in the High Atlas.
Author: Inanc Tekguç | © Educational use, non-commercial.



Agdals as fodder reservoirs.
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/// Always Moving Forward ///

Traditional systems of community-based management of natural resources, such as agdals, face significant challenges today. Conflicts and tensions between tribes and factions are a major driver of change. Additionally, the decline of traditional land-use practices, such as community-based grazing, due to shifts in lifestyle and livelihoods, is also a primary concern. Public policies promoting the privatization and commodification of agricultural land to attract agribusiness investments, and more recently, “green grabbing” by renewable energy developments, further threaten these pastoral systems, often marginalizing local resource users.

Despite these challenges, several Moroccan agdals have recently been included in the International ICCA Registry, affirming their roles as Territories of Life and Indigenous and Community Conserved Areas (ICCAs). Agdals have also been recognized as Important Plant Areas (IPAs) and Key Biodiversity Areas (KBAs) by the International Union for Conservation of Nature (IUCN) due to their significance in promoting and maintaining biodiversity and ecosystem health.

In conclusion, to protect and support agdals and community-based natural resource management systems, it is essential to further strengthen their legal recognition and protection within national legislation, ensuring that policies acknowledge and safeguard customary land rights and governance practices.

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Type of solution: Governance, Management Sector: Agroforestry, Forestry

Good practice(s): Soil management, Management alternatives, Ecosystems services, Community engagement, Protection against biotic and abiotic hazards

Preserving Morocco's Middle Atlas: The Ifrane National Park and Model Forest Initiative

A participatory governance and co-management approach for the transformation and sustainable management of the Middle Atlas forest landscape.



Ifrane National Park. High mountain pasture (foreground), natural stands of Cedrus atalantica (background).
Author: Peakvisor.com | © Educational use, non-commercial.



Atlas cedar dieback observed in forests from Middle Atlas.
Author: Forests 2011, 2, 777-796; doi:10.3390/f2030777
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/// Context ///

The Ifrane National Park (INP) is located in the Middle Atlas mountain range, in Morocco. It extends over the Western part of the Middle Atlas Mountains and areas within the provinces of Ifrane and Boulmane. The park initially covered an area of 53,800 hectares and was enlarged to 125,000 ha in 2008. The site encompasses some of the most ecologically sensitive areas such as wetlands and high-altitude forests. The territory is distinguished by a mountainous landscape, with an altitude gradient ranging from low hills to high summits with the highest point at 2,409 m. The dominant forest landscape is the Middle Atlas cedar forest (Cedrus atalantica) which extends over 114,500 hectares and represents 85% of the cedar surface area in Morocco.

The cedar forests are threatened by a combination of two phenomena: cedar dieback and resource degradation. Resource degradation is essentially due to overgrazing and the excessive harvesting of forage resources and firewood by a continuously growing population, perpetuating a survival economy. Overgrazing cause soil degradation and diminish water availability. Cedar dieback is closely correlated to water stress. Accentuated by recurring droughts over the last few years, it could worsen with the possible impact of climate change.

Land use and resource degradation in the Middle Atlas forest landscape.

Middle Atlas cedar forests are threatened by a combination of two phenomena: cedar dieback and resource degradation.

Recognizing the importance of the mountain forest natural resources and the urgent need to halt their degradation while supporting local communities, a co-management approach featuring protection (mise en défens) and compensation measures, herein referred to as "social sylviculture" has been adopted. This approach has yielded social and economic benefits for the local communities and contributed to restoring forest resources, the ecosystem services they provide and water supply. This vision was further expanded in 2011 with the creation of the Ifrane Model Forest (IMF), which encompasses the entire Ifrane Province (357,300 hectares) and has the INP at its core. Rooted in the principles and attributes of Model Forests, the IMF currently provides a structured and comprehensive platform for dialogue and action; enabling the local population, forest administration and other stakeholders to implement initiatives aimed at sustainable development, forest conservation and enhancing quality of life.

Cedar dieback is closely correlated to water stress. Accentuated by recurring droughts over the last few years, it could worsen with the possible impact of climate change.

/// Solution for a Resilient Future ///

A Model Forest is best understood as a process for bringing a diverse partnership of individuals and groups together to realize a common vision of sustainable development in a large landscape. Based on the principles and characteristics of Model Forests, the IMF's strategic directions focus on adaptable landscape and ecosystem management that combines social, environmental and economic needs of local communities with long-term sustainability of large landscapes. All activities to mitigate threats and preserve the functionality of the Middle Atlas forest landscape employed a participatory governance and co-management approach. Example of such activities include:

1. Collaboration with Silvopastoral Management Associations (SMAs)

Collaboration with SMAs led to the establishment of an integrated system involving 11 legally recognized associations. Currently, these associations operate under a partnership with the High Commission for Water, Forestry and desertification. SMAs recognized the unsustainability of traditional grazing cycles which resulted in increased pressure on pastoral and forest lands. Shepherds have acknowledged these challenges and expressed needs for solutions, including rotational grazing practices to improve grazing areas and enhance incomes.

2. Activities to enhance natural regeneration of the Atlas cedar

A cedar stand adjacent to a grazing area was fenced to prevent grazing. Few years after grazing stopped, natural regeneration began mainly in open areas under cedar canopy. This initiative demonstrated that in areas where cedar occurs naturally, the cessation of grazing can promote and lead to natural regeneration. Natural regeneration significantly reduces CO2 emissions associated with nursery plant production, soil preparation and irrigation. It is therefore beneficial to limit grazing in areas where natural regeneration can be achieved. Afforestation should be reserved for situations where natural regeneration is challenging or where long-term cessation of grazing is not technically or socially viable.

3. Activities to enhance grazing capacity

Pastoral lands are experiencing significant degradation due to the disruption of traditional vertical transhumance practices influenced by changes in valleys agriculture. This has resulted in overgrazing with over 20,000 sheep grazing in the same area all year round. To address this issue, the IMF implemented several measures aimed at improving grazing practices and enhancing pasture quality. Among those measures, is the establishment of a pilot area where diverse, native herbaceous plant species have been planted to improve pastoral conditions. Watering troughs for livestock were also placed on strategic locations to encourage greater rotation of animals and thereby promoting overall herd health and productivity. Moreover, planting a 10-kilometer row of Atlas cedars has been initiated in an effort to delineate grazing areas and enhance overall grazing capacity in the region.



Recovery of vegetation after protection (in the foreground) compared to the degraded land (background) – Middle Atlas.
Author: S. El Khiyari | © Educational use, non-commercial.

A Model Forest is best understood as a process for bringing a diverse partnership of individuals and groups together to realize a common vision of sustainable development in a large landscape.

4. Activities to restore maritime pine burnt area

After a fire ravaged a 1,000-ha area in 2022, soil fertility significantly declined, hindering natural regeneration of maritime pine. The fire also caused alterations in species composition. Consequently, artificial replanting of maritime pine was carried out. Newly planted seedlings showed limited growth in early years after-planting. Soil fertility was improved by planting bare root seedlings pre-soaked in a mixture of mature forest soil and water. Moreover, preventive measures such as fire barriers and rapid-response fire tracks to mitigate future fire risks were implemented to support natural ecosystem recovery.

5. Activities to enhance local livelihoods

SMAs established small-scale lavender and saffron plantations to test their impact on biodiversity and improvement of family income (production of lavender essential oils and saffron spice). Initial planting of lavender seedlings faced difficulties adjusting from nursery to field conditions. To aid root system

The Ifrane Model Forest: a participatory governance and co-management approach to preserve Middle Atlas forest landscape.

Activities to mitigate threats and preserve the functionality of the Middle Atlas forest landscape employed a participatory governance and co-management approach.



Burnt area restoration in the Middle Atlas – replanting maritime pine (Pinus pinaster).
Author: https://www.medmodelforest.net/en | © Educational use, non-commercial.

Strategic directions of the IMF focus on adaptable landscape and ecosystem management that combines social, environmental and economic needs of local communities with long-term sustainability.

establishment and vegetative growth, rescue irrigation is being used on lavender seedlings. Both pilot plantations showed satisfactory preliminary results in terms of production yield and product quality. The yield of saffron spice reached 4 kg/ha after 3 years of cultivation. Future plans include scaling up the production capacity of lavender and saffron cultivations, diversifying products and replicating the model elsewhere

/// Always Moving Forward ///

While substantial progress has been made in integrating social needs and ecological restoration in the Middle Atlas forest landscape, several strategic steps with focus on continuous collaboration between all stakeholders, monitoring, evaluation and scaling successful models are needed in order to consolidate gains and to ensure the long-term success and sustainability of the restoration activities.

- 1. Strengthen community engagement and expand participatory governance and co-management
- Establish more SMAs and integrate them into the broader forest management strategy.
- Promote participatory governance models to include more stakeholders in decision-making processes,
- Invest in capacity-building programs for local communities, government officials, and other stakeholders,
- Engage local communities in awareness programs focused on sustainable forest management and the benefits of biodiversity,
- Encourage local schools and institutions to include environmental education in their curricula.

2. Support and scale up natural regeneration of Atlas cedar

- Monitor the fenced areas regularly to assess the progress of natural regeneration.
- Identify and prioritize more areas suitable for natural regeneration and apply the same fencing and grazing cessation strategies.

3. Improve grazing capacity and enhance ecosystem services and biodiversity

- Expand pilot areas planted with herbaceous plant species and monitor their impact on pasture quality.
- Assess the effectiveness of installing watering troughs in promoting rotational grazing.
- Implement broader ecosystem management practices that enhance biodiversity and ecosystem services.

4. Follow up on burnt areas restoration

- Monitor the growth and health of newly planted maritime pine seedlings.

Long-term initiatives for sustainable development in the Middle Atlas.





Crocus sativus – Saffron spice.
Author: https://imfn.net/regional-networks/ifrane-model-forest/
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Ifrane Model Forest – Middle Atlas.
Author: https://www.medmodelforest.net/en | © Educational use, non-commercial.

- Implement ongoing soil fertility improvement measures and monitor their effectiveness.
- Regularly review and update fire prevention and rapid-response strategies based on new research and technology.

5. Enhance Local Livelihoods

- Provide continuous support and technical advice to lavender and saffron growers.
- Develop marketing strategies to promote lavender essential oils and saffron spice to increase market access and profitability.
- Conduct trials on other potential crops that can diversify income sources for local communities.

6. Climate Change and resilience

- Conduct research on the potential impacts of climate change on Mountain's systems.
- Develop adaptation and mitigation strategies to minimize impacts of climate change.
- Promote research and development on sustainable land-use practices that balance ecological, social and economic needs.

By promoting adaptive management strategies and fostering resilience among local communities, the IMF serves as a living-lab for sustainable development and a model for similar initiatives worldwide.

Strategic steps with focus on continuous collaboration between all stakeholders are needed to ensure the long-term success and sustainability of the restoration activities.

7. Monitor and evaluate progress

- Establish a comprehensive monitoring and evaluation framework to track the progress of all initiatives.
- Explore innovative solutions, including the use of technology for monitoring and management.
- Regularly assess the impact of activities on forest health, biodiversity and local livelihoods.
- Adjust strategies based on evaluation results and feedback from local communities and stakeholders.

8. Secure funding and partnerships

- Seek long-term funding and partnerships with national and international organizations to ensure the sustainability of initiatives.
- Promote public-private partnerships to leverage additional resources and expertise.

9. Implementation and Scaling

- Develop detailed action plans for each initiative with clear timelines, responsible parties, and measurable outcomes.
- Ensure alignment of these action plans with broader strategic goals and objectives.
- Facilitate knowledge sharing and best practices through regional and international networks.
- Identify successful pilot projects and develop strategies for replicating these models in other regions.
- Document and share case studies and success stories to inspire and guide similar initiatives elsewhere.

The co-management approach, coupled with sustainable practices and innovative solutions, ensures the protection of vital natural resources while enhancing the quality of life for local communities.

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Partners: CIHEAM – MAICH – Mediterranean Agronomic Institute of Chania

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Type of solution: Governance Sector: Agroforestry
Good practice(s): Management alternatives, Ecosystems services, Community engagement

The Agdal pastoral system in Morocco: community-based natural resource management for socio-ecological resilience

Agdal system exemplifies a holistic approach to natural resources conservation, sustainable development, participatory governance, conflict resolution and social justice.



Sheep grazing in the High Atlas.
Author: Inanc Tekguç | © Educational use, non-commercial.



Beginning of the transhumance journey near the Jebel Saghrou mountains, along the road leading to the agdal.
Author: Inanc Tekguç | © Educational use, non-commercial.

/// Context ///

Socio-ecological landscapes in the Mediterranean area have evolved over long periods through the balanced interaction between humans and nature. These landscapes have been shaped and maintained by generations of farmers and herders using diverse natural resources and locally adapted management practices. These systems have resulted in the preservation of outstanding landscapes, indigenous knowledge systems, and resilient ecosystems.

A prime example of these socio-ecological landscapes is the pastoral Agdals in Morocco. Found in North Africa, especially in the High Atlas Mountains in Morocco, Agdals are community-based natural resource management systems where people have developed effective cultural and governance practices. The functioning of Agdals is based on the seasonal closure of pasturelands to protect and conserve natural resources, particularly grasslands. This practice ensures sustainable resource use by controlling grazing periods and allowing the land to regenerate. Agdals are managed by local communities through customary rules and agreements.

The benefits provided by the agdal system include:

- Empowerment of community members through participatory decision-making processes.

Agdals are community-based natural resource management systems where people have developed effective cultural and governance practices.

This practice ensures sustainable resource use by controlling grazing periods and allowing the land to regenerate.

- Conflict resolution and cooperation among community members.
- Preservation of vegetation cover and biodiversity, ensuring ecological health and resilience.
- Creation of ecological mosaics through diverse land uses.
- Provision of fodder, especially critical during periods of scarcity.
- Social cohesion, strengthening communal bonds and a sense of belonging.
- More equitable distribution of benefits, ensuring most community members have access to resources.
- Increased economic activities through sustainable practices.

Most importantly, agdals enhance the socio-ecological landscape's resilience and adaptive capacity in the face of the natural hazards, such as recurrent droughts, extreme cold, and floods, that have historically affected this region and that are intensifying due to climate change. This is achieved through flexible management strategies, informed by the use of traditional ecological knowledge, that respond to environmental constraints and social dynamics.

/// Solution for a Resilient Future ///

Moroccan agdals represent a sophisticated and time-tested form of community-based management of natural resources, significantly contributing to both social and ecological resilience.

1. Participatory Decision-Making and Conflict Resolution

Agdals are managed through a participatory decision-making process that involves the entire community; however, men typically assume a central role due to cultural traditions. The tribal assembly, or jmaa, composed of heads of households, is the political body that establishes the rules and supervises the implementation of agdal practices. By engaging all stakeholders, agdals empower citizens and foster a sense of ownership and responsibility towards local resources. This participatory approach not only improves resource productivity but also ensures its sustainable use and fair distribution among users, thus enhancing community resilience.

This system plays also a crucial role in resolving conflicts and promoting cooperation within and between communities. Customary assemblies are the place for negotiating and exercising rights collectively, while a system of monitoring and sanctions ensures compliance with agreed rules. Exclusive village control over agdals helps manage inter-community conflicts by establishing clear territorial and social boundaries (Auclair et al., 2011).

2. Conservation of Natural Resources and Diversification of Land Uses

Agdals enhance ecological resilience through the conservation of natural resources and the diversification of land uses. One of the key aspects of agdal management is the strategic prohibition of herding during critical periods of the vegetation cycle. For example, the Yagour agdal is closed from the end of March for three months, encompassing the crucial month of May when pastoral plants undergo significant growth. This seasonal prohibition allows plants to flower, reproduce, and germinate without the pressure of grazing. Consequently, the vegetation within agdals can regenerate more robustly compared to non-protected areas, leading to higher plant diversity and denser vegetation cover.

In addition, the system creates an ecological mosaic across the landscape by implementing different agdals

The Agdal pastoral system in Morocco: community-based natural resource management for socio-ecological resilience.



Mobile pastoralism in the High Atlas.
Author: Inanc Tekguç | © Educational use, non-commercial.

This participatory approach not only optimizes resource productivity but also ensures sustainable extraction and fair distribution among users, thus enhancing community resilience.

with staggered opening and closing times. This mosaic approach encourages the growth and regeneration of various species at different times and places, promoting a diverse range of habitats and microclimates. This ecological mosaic effect is critical to maintaining the genetic diversity of plant populations (Dominguez, 2012).

Finally, they have usually provided vital support for livestock by ensuring a reliable supply of fodder during critical times such as summer droughts. Furthermore, the manure from agdal-fed animals enriches agricultural lands, improving soil fertility and crop productivity.

3. Resources and Equity

The collective nature of agdals ensures that all community members have equal access to pastures and other resources, promoting social justice among herders. Agdal prohibitions are negotiated and agreed upon by the community, and rules for resource exploitation, such as quotas for harvesting leaf fodder, are established on the basis of egalitarian values. In this way, the system embodies and reflects the intricate values of social justice and equity, which contribute to the social sustainability and resilience of rural communities (Dominguez, 2012).

4. Adaptive Capacity

Herders' extensive knowledge of grazing plant growth

The flexible and adaptive nature of agdal governance enables communities to respond effectively to social and ecological disturbances, maintaining ecosystem integrity and resource availability.



Traditional fodder gathering.
Author: Inanc Tekguç | © Educational use, non-commercial.

cycles and local climate patterns inform agdal resource management, allowing communities to adjust grazing intensity and time restrictions based on ecological feedback. The flexible and adaptive nature of agdal governance allows communities to respond effectively to social and ecological disturbances, while maintaining ecosystem integrity and resource availability (Plieninger et al., 2022).

5. Contribution to the Local Economy

Agdals significantly contribute to the local economy by providing essential fodder during critical periods, enriching agricultural lands with manure, and generating income through ecotourism. The system brings in a substantial portion of annual fodder, particularly when other pastures are unproductive, thereby stabilizing the local economy and supporting community livelihoods.

In conclusion, Moroccan agdals exemplify a robust and adaptive system of collective land management that enhances both social and ecological landscape resilience. Through participatory governance, conflict resolution, resource conservation, and equitable resource distribution, agdals empower communities, foster social cohesion, and ensure the sustainable use of natural resources, making them a vital tool for addressing the challenges posed by climate change and socio-economic crises.

/// Always Moving Forward ///

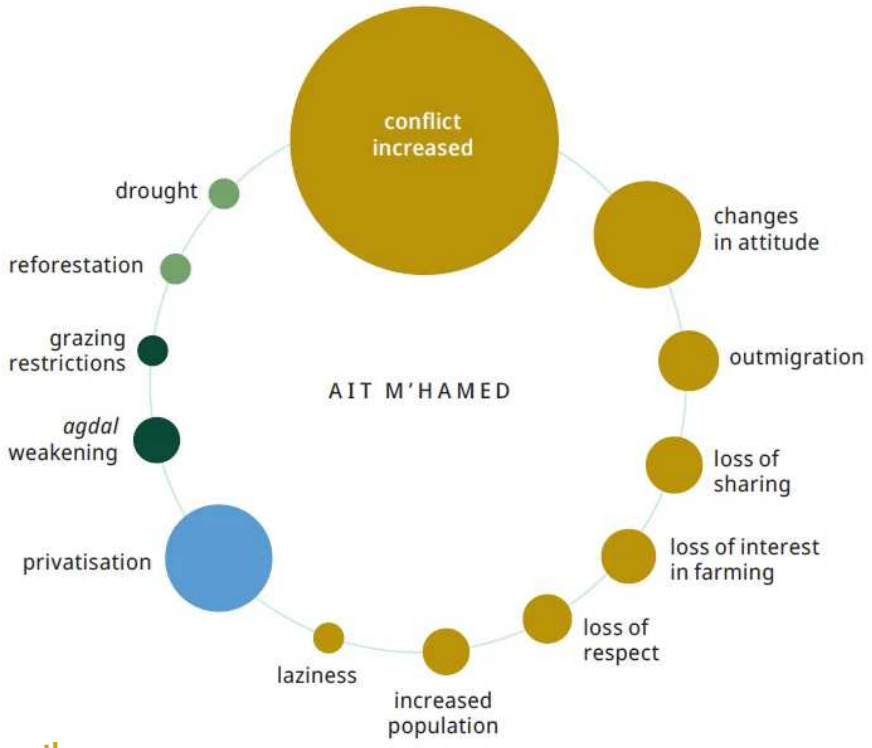
Agdals play a crucial role in preserving biodiversity, maintaining resilient ecosystems, and supporting the livelihoods of local communities. However, these systems are currently facing numerous threats that jeopardize their sustainability.

A major threat to the agdals is the exodus of young people to urban areas due to the lack of socioeconomic opportunities and harsh living conditions in the High Atlas. This migration leads to the loss of traditional knowledge and practices essential to the management of these systems. The abandonment of transhumance, a traditional practice where pastoralists move their herds seasonally, leads to the neglect of temporal grazing restrictions essential for agdal sustainability. This results in overgrazing, plant degradation, and biodiversity loss. Climate change further exacerbates the situation, with harsher summer droughts increasing conflicts over agdal governance and access to water. The unpredictability of rainfall and extreme temperatures strain the delicate balance needed to maintain these systems. Finally, despite their contributions to biodiversity conservation and sustainable land use, agdals suffer from insufficient recognition and support from governmental and international bodies. Policies often favor privatization and agribusiness, marginalizing local resource users and undermining traditions of collective land management. Global market forces that favor intensive agriculture over sustainable practices also put immense pressure on the agdals.

Therefore, to protect and support agdals, several measures should be undertaken. Firstly, it is key to strengthen the legal recognition and protection of agdals within national legislation, ensuring that policies acknowledge and safeguard customary land rights and governance practices. Raising awareness about the importance of agdals through educational campaigns and public outreach initiatives can help highlight their role in biodiversity conservation, cultural preservation, and sustainable development, fostering greater public support. Increased collaboration among communities, government agencies, nongovernmental organizations, and international bodies is critical to securing financial resources and technical support; funding mechanisms should be designed to meet the needs and priorities of local communities, ensuring the sustainability of agdal systems. Socioeconomic development in the High Atlas region is pivotal to reduce youth migration and retain traditional knowledge; programs that create jobs, improve living conditions, and provide essential services can make rural life more sustainable and attractive. In addition, it is essential to integrate agdals into national

It is key to strengthen the legal recognition and protection of agdals within national legislation, ensuring that policies acknowledge and safeguard customary land rights and governance practices.

Challenges identified by inhabitants from the commune of Ait M'hamed.
Author: Global Diversity Foundation & Moroccan Biodiversity and Livelihoods Association
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Protecting and further developing these systems is essential to maintaining the environmental sustainability, cultural heritage, and local livelihoods of the High Atlas region.

strategies, such as the Moroccan government's Green Generation Strategy 2020-2030, which aims to modernize agriculture. Measures to support agdals include building water infrastructure, providing mobile schools and health services, and restoring vegetation in pastoral areas.

In conclusion, community management of agdals is a socio-culturally resilient, economically sustainable and ecologically enriching land use approach. Protecting and further developing these systems is essential to maintaining the environmental sustainability, cultural heritage, and local livelihoods of the High Atlas region. It is critical to design effective strategies so that the Agdal will continue to thrive and adapt, offering valuable lessons on sustainable resource management and community resilience.

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Reconnecting nature: restoring the Insubria ecological corridor in northern Italy

Reversing biodiversity loss and enhancing ecosystem services between the Alps and Ticino Valley.



Project study area, in northern Italy.
Author: Archivio Lipu | © Educational use, non-commercial.



Road infrastructure – major barrier to wildlife movements.
Author: Marco Tessaro | © Educational use, non-commercial.

/// Context ///

Animal and plant species are disappearing at an unprecedented rate, with irreversible consequences for our future. It is estimated that between 17 and 35% of all species could be extinct by 2050 if no action is taken. Parks and nature reserves alone are not enough to tackle this threat. The problem is exacerbated by the rapid expansion of urban areas. Cities are spreading linearly, and new developments – residential, industrial and commercial – and infrastructure projects consume more than ten hectares of natural or agricultural land every day. This leads to the gradual fragmentation of natural areas, confining wildlife. Animals need to move freely to feed, drink, breed and migrate. Similarly, plant communities need to move, albeit on a different time scale, to adapt to ever-changing environmental conditions. Climate change is an additional risk factor for many species that are forced to move to respond to these dynamics. Preventing additional land loss will therefore be crucial. Without a network linking large and small natural ecosystems, animals and plants face increasing isolation.

To address this critical issue, the LIFE TIB project –

Animals need to move freely to forage, drink, breed, and migrate. Similarly, plant communities also need to move, albeit on a different time scale, to adapt to ever-changing environmental conditions.

Environmental fragmentation: a threat to biodiversity.

"Trans Insubria Bionet – Habitat improvement and connectivity along the Alps – Ticino Valley ecological corridor in Insubria" was designed and implemented. The project was supported by thirty-five municipalities from the Insubria ecological corridor area, the Ticino River Valley Regional Park, the Campo dei Fiori Regional Park, the Professional Association of Architects and Engineers of the Province of Varese, BirdLife Europe, and the European Foundation Centre.

The goal of the project was to restore the functionality of the Insubria corridor, situated in one of the most densely inhabited and productive areas in Italy. The concrete application of the ecological corridor concept improved the ecosystem services provided by natural habitats, with great benefits for humans as well: cleaner air and water, a more stable micro-climate, flood control and mitigation of extreme weather events, improved soil fertility.

Without a network connecting both large and small natural ecosystems, animals and plants face progressive isolation.



Underpass – Installation.
Author: Marco Tessaro | © Educational use, non-commercial.



Underpasses for medium-size animals.
Author: Boutheina Stiti | © Educational use, non-commercial.

/// Solution for a Resilient Future ///

Extensive efforts were made at both field and policy levels to restore the functionality of the Insubria ecological corridor. Habitat restoration interventions were planned and implemented, focusing on target wildlife species. Various actions were designed to ensure that mammals, birds, herpetofauna and invertebrates could find suitable habitats throughout the corridor, allowing them to move freely:

1. Barriers such as underpasses, power lines and watercourses were “defragmented” to be more permeable to wildlife:

1.1 Animal underpasses were installed under roads to prevent road kills of migrating amphibians and mammals. Moreover, wildlife paths were built under bridges above flood levels to facilitate animal movement during high waters:

- Five underpasses for amphibians were prefabricated using concrete tunnels (50 cm wide).
- Five underpasses for medium-sized animals were constructed using the pipe-jacking technique (diameters 1 to 1.5 m).
- Four existing underpasses were repaired by using topsoil, planting vegetation and creating infrastructure to funnel animals towards underpass entrances.
- Five interventions along watercourses were implemented by placing large boulders in streambeds to facilitate wildlife crossings where watercourses are interrupted by bridges.

1.2. Power lines were insulated and made more visible to avoid bird electrocutions. Spiral-shaped bird dissuaders that produce a whistling sound, making power lines more noticeable even in poor visibility, were installed.

The Trans Insubria Bionet project's holistic solution for wildlife habitat restoration and policy integration.

In order to offset the impact of the fenced area following planting and to alleviate pressure on the forest, it may be advisable to promote alternative activities that will enhance local incomes.

2. Habitats such as wetlands and dry-stone walls were enhanced to become more diverse and attractive to wildlife.

2.1 Wetlands within a few kilometers of each other were connected and their ecological status improved:

- Eigth new ponds ranging from 10 to 90 m2, with irregular shallow shorelines and shaded by tree trunks or boulders were created for amphibians.
- Two water bodies were enlarged by removing organic material from their bottom to reverse their natural filling-in process, at the same time, invasive alien plant species were removed from their borders.

2.2. Dry-stone walls were restored (80 cm high and 60 cm wide) using local natural materials. They were also cleared from overgrown vegetation to ensure adequate drainage.

3. Forestry interventions to maintain and increase old hollow trees and dead wood micro-habitats favourable to the survival of saproxylic species:

- About 2,500 interventions (uprooting, cutting, and girdling) were carried out to facilitate the ageing, death, and natural decay of non-native tree species creating nesting cavities and putting up artificial nests for a number of target species (about 950 trees were affected).
- 150 log pyramids were built to simulate old rotting stumps and provide ideal breeding habitat for stag beetles.

Should the concession with the community be unfeasible and lacking in clear objectives, the rehabilitation process could prove to be an expensive failure.

- 970 white willow trees were planted and 30 adults were pollarded to provide suitable breeding habitat for several bird and insect species.

4. Invasive alien plant species were removed to create space for indigenous flora and to enrich soil fertility:

- Two highly invasive aquatic plants were removed over two consecutive flowering seasons using hand and mechanical removal techniques.

5. Integrating wildlife preservation into urban and community planning:

- Along with on-the-ground interventions, significant emphasis was placed on policy and governance initiatives integrating the preservation of the corridor into community planning. Urban planners worked extensively with each community council within the corridor, explaining the significance of Natura 2000 and the Regional Ecological Network and assessing their planning documents.

6. Monitoring efforts:

- Short-term monitoring has already shown positive results, with increased and healthier populations of target species using the corridor. Medium-term monitoring, conducted five years after the project's completion, provided quantitative data supporting these findings. Long-term monitoring will continue to evaluate the durability of the corridor restoration interventions.
- The restoration of the corridor has supported more robust wildlife communities, which in turn has made the system of exchange between human communities and their environment more resilient and economically viable. The ecological corridor is now recognized in the land use plans of all municipalities in the area, with a requirement to perform environmental impact assessments wherever necessary, not just within Natura 2000 sites and other protected areas.

Aim: to enhance knowledge and monitoring through workshops and technical assistance, thereby improving forest resources management.

/// Always Moving Forward ///

While significant progress has been made in restoring the Insubria ecological corridor, continued efforts are essential to ensure the long-term success and sustainability of the restoration initiatives. The following outlines the next steps and future directions for maintaining and enhancing the corridor:

- Continued Monitoring and Adaptive Management
  Regular biodiversity surveys are crucial for tracking target species populations and evaluating the success of restoration efforts. Periodic habitat quality assessments, such as water quality in wetlands, vegetation health, and the integrity of dry-stone walls, are also necessary. Long-term monitoring protocols to guide management decisions and adjust restoration techniques as needed, should be established. Engaging local communities in these monitoring activities will promote a sense of ownership and stewardship over the corridor.
- Expansion and Connectivity
  Acquiring additional land adjacent to the existing corridor will expand its area and improve habitat connectivity. Establishing buffer zones around the corridor will protect it from threats such as urban development, pollution, and invasive species. Additionally, restoring more ecological corridors connected to the Insubria corridor will create a larger habitat network and thus support wider species movement and genetic exchange.

Sustaining and expanding conservation efforts in the Insubria ecological corridor.



Installation of waterproof Geomembrane sheet and gravel – Lentate Verbano pool – Municipality of Sesto.
Author: Marco Tessaro | © Educational use, non-commercial.

- Enhancing Habitat Diversity
  Continued creation and restoration of interconnected wetlands will support diverse amphibian and bird populations. Implementing forestry practices that promote the growth of native tree species and the development of deadwood habitats will further enhance biodiversity. Innovative techniques, such as integrating green infrastructure elements like green roofs and walls into urban areas, will provide additional habitats for wildlife. Rewilding initiatives, which allow natural processes to shape the landscape, and enhance habitat diversity and resilience should be also considered.
- Community Education and Policy Advocacy
  Developing educational programs in collaboration with local schools and universities will raise awareness about



Survey – Vegetation structure.
Author: Marco Tessaro | © Educational use, non-commercial.



Monitoring – bat box.
Author: Federica Luoni | © Educational use, non-commercial.

the importance of ecological corridors and biodiversity conservation. Public outreach, through community events, workshops, and volunteer opportunities, will engage the public in conservation activities and foster a culture of environmental stewardship. Policy advocacy should focus on integrating ecological corridor conservation into broader land-use planning and development policies, and advocating for increased funding and support from government agencies, NGOs, and private sector partners.

- Addressing Climate Change
  Implementing climate-smart restoration techniques will enhance the corridor's resilience to climate change, such as planting drought-resistant species and restoring wetlands to buffer against extreme weather events.

  Highlighting the corridor's role in carbon sequestration will underscore its contribution to climate change mitigation. Conducting research on the potential impacts of climate change on the corridor's ecosystems and species will help develop strategies to mitigate these impacts. Exploring innovative solutions, including the use of technology for monitoring and management, will enhance the corridor's adaptability to changing environmental conditions.

By implementing the above-mentioned steps, the Insubria ecological corridor will continue to flourish, sustaining a viable wildlife habitat and enhancing the overall health and resilience of this socio-ecological system.

Next steps and future directions: adaptive management, expansion and connectivity, enhancing habitat diversity, community education, policy advocacy, addressing climate change.

Continuous efforts are essential to ensure the long-term success and sustainability of the Insubria ecological corridor.

Further information

- LIFE TIB project website. http://www.lifetib.it/En/index.html (Accessed 11 June 2024)
- Layman's report: "Trans Insubria Bionet – Habitat improvement and connectivity along the Alps – Ticino Valley ecological corridor in Insubria". URL: http://www.lifetib.it/DOWNLOAD/ConvegnoFinale/Laymans_reportWEB.pdf (In Italian)

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Partners: CIHEAM – MAICH – Mediterranean Agronomic Institute of Chania

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Type of Solution: Management Sector: Forestry

Good practice(s): Water management, Management alternatives, Ecosystems services, Community engagement, Protection against biotic and abiotic hazards

Restoring Insubria ecological corridor in northern Italy

Connection and improvement of habitat along the ecological corridor between the Alps and Ticino Valley.



The project area seen from Campo dei Fiori.
Author: Archivio Lipu | © Educational use, non-commercial.



Road infrastructure – major barrier to wildlife movements.
Author: Archivio Lipu | © Educational use, non-commercial.

/// Context ///

Animal and plant species are disappearing at an unprecedented rate, leading to irreversible consequences for our future. Unless preventive measures are adopted, an estimated 17 to 35% of all species may be extinct by 2050. Parks and nature reserves alone are insufficient to face this threat. Compounding the issue is the rapid expansion of urban areas. Cities are spreading in a linear manner, and new developments—residential, industrial, and commercial—along with infrastructure projects, consume over ten hectares of natural or agricultural land each day. This results in the gradual fragmentation of natural areas, confining wildlife. Animals need to move freely to forage, drink, breed, and migrate. Similarly, plant communities also need to move, albeit on a different time scale, to adapt to ever-changing environmental conditions. Without a network connecting both large and small natural ecosystems, animals and plants face progressive isolation.

To address this critical issue, the Trans Insubria Bionet project was designed and implemented. Its objectives were:

- Reverse biodiversity loss by restoring environmental connectivity in one of the main ecological corridors linking the Alpine and Continental bioregions.
- Restore the functionality of the Insubria corridor, situated in one of the most densely inhabited and productive areas in Italy.
- Improve the conservation status of areas of high natural value, such as Natura 2000 Network sites.

/// Solution for a Resilient Future ///

Extensive efforts were made at both the field and policy levels to restore the functionality of the Insubria ecological corridor. Specific habitat restoration interventions were planned and implemented, focusing on target wildlife species. Various actions were designed to ensure that mammals, birds, herpetofauna, and invertebrates could find suitable habitats throughout the corridor, allowing them to move freely:

- Natural habitats were enhanced to become more complex, diverse, and attractive to wildlife.
- Wetlands were connected and their ecological status improved.
- Dry stone walls were rebuilt or cleared of overgrown vegetation, and forests were enriched with hollow trees and nursery logs.
- Invasive alien plant species were removed, creating space indigenous flora and enriching soil fertility. Infrastructure was “defragmented” to be more permeable to wildlife: power lines were made conspicuous and harmless to avoid bird electrocutions, animal underpasses were installed under roads to prevent road kills of migrating amphibians and mammals, and wildlife paths were built under bridges above flood levels to facilitate animal movement during high waters.

Along with on-the-ground interventions, significant emphasis was placed on policy and governance initiatives integrating the preservation of the corridor into community planning. Urban planners worked extensively with each community council within the corridor, visiting them, explaining the significance of Natura 2000 and the Regional Ecological Network, and assessing their planning documents.

The restoration of the corridor has supported more robust wildlife communities, which in turn has made the system of exchange between human communities and their environment more resilient and economically viable.

Short-term monitoring has already shown positive results, with increased and healthier populations of target species using the corridor. Medium-term monitoring, conducted five years after the project's completion, provided quantitative data supporting these findings. Long-term monitoring will continue to evaluate the durability of the corridor restoration interventions.

The ecological corridor is now recognized in the land use plans of all municipalities in the area, with a requirement to perform environmental impact assessments wherever necessary, not just within Natura 2000 sites and other protected areas.

In 2014, 45 municipalities, the provincial government of Varese, the protected areas, LIPU-BirdLife Italy, and Fondazione Cariplo entered into a voluntary Network Contract (Contratto di Rete), formally committing to protect the ecological corridor.



Wildlife monitoring – Black woodpecker (Dryocopus martius) – Insubria region (Italy).
Author: Archivio Lipu | © Educational use, non-commercial.



Raising awareness on the ecological corridor.
Author: Archivio Lipu | © Educational use, non-commercial.

/// Always Moving Forward ///

With the successful implementation of the project and its significant strides in restoring the functionality of the Insubria ecological corridor, the focus now shifts to sustaining and expanding these efforts.

Here's a glimpse into what lies ahead:

- Sustainability remains at the forefront, with continued monitoring and adaptive management practices ensuring the long-term viability of restored habitats and the ecological corridor.
- More efforts will focus on identifying and addressing remaining barriers to wildlife movement, enhancing connectivity between ecosystems and fostering resilience in the face of future challenges.
- Community engagement remains central, empowering local stakeholders through decision-making involvement, biodiversity conservation awareness, and educational initiatives.
- Advocating for supportive policies and legislation is crucial for scaling up conservation efforts, integrating ecological corridor concepts into land-use planning and environmental policies.
- Embracing innovation and fostering collaboration will drive progress, exploring new technologies, research methodologies, and partnerships to enhance conservation impact.

Further information

- LIFE TIB project website. http://www.lifetib.it/En/index.html (Accessed 24 May 2024)
- Layman's report: "Trans Insubria Bionet – Habitat improvement and connectivity along the Alps – Ticino Valley ecological corridor in Insubria". URL: http://www.lifetib.it/DOWNLOAD/ConvegnoFinale/Laymans_reportWEB.pdf (In Italian)

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Climate change adaptation measures in Mediterranean mid-mountains of NE Spain

Implementing and testing landscape management measures for climate change adaptation in marginal mid-mountain areas of northeast Spain.



Location of mid-mountain regions of Spain where adaptation measures were tested and implemented. | Author: LIFE MIDMACC | © Educational use, non-commercial.



Mid-mountain landscape in Requesens, Catalonia.
Author: CREAF | © Educational use, non-commercial.

/// Context ///

The mid-mountain areas of southern Europe are highly vulnerable to climate change, with some experiencing depopulation due to the abandonment of traditional primary sectors. This has led to landscape homogenization and decreased environmental resilience. Southern European mountain areas are considered highly vulnerable due to, among other things, the decrease in available water, the duration and severity of droughts or the increased frequency of fires. In addition, these areas have suffered from rural depopulation and the reduction of socio-economic activities in the last decades, leading to the progressive loss of the mosaic landscape and the revegetation of the mountain slopes. These processes have reduced the environmental services provided by mountain areas, such as the provision of water to the lower parts of the basins, as well as the sustainability of agricultural and forestry systems and their economic income.

LIFE MIDMACC project promotes adaptation through the implementation and testing of different landscape management measures to meet challenges posed by climate change in marginal mid-mountain areas of Spain (La Rioja, Aragon and Catalonia), while improving their socio-economic development. Some of the main objectives are:

Pasture restoration involves the clearing of bush and the introduction of extensive livestock to reduce fire risk and the vulnerability of mountain areas, restoring a mosaic landscape.

Enhancing Resilience: Adaptation Strategies for Southern European Mid-Mountain Landscapes.

- Assess the socio-economic and ecological effectiveness of the applied measures through widespread monitoring and modelling.
- Involve the regional managers and stakeholders in the design, development and evaluation of adaptation measures, through decision-making regional committees.
- Develop an integrated climate change adaptation guide for mid-mountain areas.

However, the main objective is to promote and test adaptation measures for the recovery of a landscape in mosaic more environmentally and socio-economically resilient by:

- Restoring pasture by clearing scrub and introducing extensive livestock farming.
- Forest management for fire risk prevention and maintenance with extensive livestock production.
- Introduction and/or optimization of vineyard management in mountain areas.

Adaptive forest management, through undergrowth clearing and tree thinning, seeks fuel discontinuity to mitigate fire risk, enhance pasture growth, and alleviate forest water stress.



Cows for pasture recovery in Garcipollera pine forest (Huesca, Aragonese Pyrenees).
Author: IPE-CSIC | © Educational use, non-commercial.



Mediterranean oak forest with unmanaged undergrowth in Requesens (Girona).
Author: CREAF | © Educational use, non-commercial.

/// Solution for a Resilient Future ///

The mountain regions of southern Europe are highly vulnerable to climate change. In the Mediterranean, water resources have declined due to prolonged droughts and intensified heat waves, increasing the risk of forest fires and ecosystem degradation. Additionally, traditional land management practices are declining, leading to the loss of resilient mosaic landscapes. To address these challenges, the LIFE MIDMACC project focuses on climate change adaptation in mid-mountain regions by introducing innovative landscape management techniques in three strategic areas of the southern Pyrenees and north-eastern Iberian Peninsula: Aragon, Catalonia, and La Rioja.

Pasture Restoration: The restoration of pastures affected by scrub growth involves clearing the scrub and introducing extensive livestock farming. Pilot tests in La Rioja and Aragón evaluated pasture restoration as a climate change adaptation measure. Mechanical scrub clearing and monitoring plots were used to assess the impact of different sheep livestock densities on plant species richness, composition, nutritional quality, biomass productivity, pasture value, runoff, erosion, soil water, carbon, and nitrogen content. Additionally, this strategy improved habitat diversity and moisture content, enhancing resilience to climate change and potentially increasing water resources, thereby reducing fire risks. These treatments significantly improved soil quality by increasing soil organic carbon and nitrogen content, along with increased surface runoff in pastures without escalating erosion rates. Moreover, managed pastures showed an increase in herbaceous species cover compared to adjacent areas without livestock density. Socio-economic analyses revealed variable costs associated with clearing activities, underscoring the economic challenges faced by livestock farmers, often requiring European subsidies for viability.

Forest Management: Pilot tests in forest management were implemented in representative forested areas of the Mediterranean mid-mountain region, such as black pine, black poplar, and holm oak forests. The actions primarily involved selective thinning and underbrush clearing to reduce tree density and promote mature structures with larger trees. This aimed to reduce fuel continuity and fire risk, promote grass development, and improve cattle management. The application of adaptive silvicultural practices significantly reduced forest vulnerability to both wildfire and drought, improving the physiological condition of treated forests and enhancing pest resistance. Monitoring eco-environmental parameters in different forest pilot experiments demonstrated an increase in soil water availability, particularly in grassy plots, reducing vegetation flammability and improving the health of managed forest stands. The socioeconomic analysis emphasized the need to integrate pastoral management into managed forests to maintain the effectiveness of actions in the medium term. Overall, the costs of silvicultural practices depend on terrain characteristics and treated underbrush, with a high dependency on European subsidies and limited incentives for managing Mediterranean mid-mountain forests. Additionally, trees in Mediterranean mid-mountain pastures provide cattle shelter from summer heat, yet pastures with trees are not recognized for subsidies under the Common Agricultural Policy.

Introduction and/or Optimization of Vineyards: In vineyards, regenerative agricultural practices were implemented in Catalonia (Empordà and Llívia) and La Rioja (Tudelilla and Clavijo). Various agronomic management practices, such as different cover crops and vine training systems, were tested to elucidate key elements of this climate change adaptation strategy. Terrace restoration and the establishment of new vineyards improved mosaic landscapes, increasing habitat diversity and reducing forest fire risk. At the plot scale, soil-conserving techniques with cover crops increased soil organic matter and micronutrients, enhancing microbial

Adapting mediterranean mid-mountains to climate change through pasture recovery, forest management and vineyards.

The use of livestock in the management of pastures and forests extends the effects of forestry and helps with long-term sustainability.

Vineyard cover crops increase soil organic matter, micronutrients, microbial diversity, water retention and combat erosion.



Vineyard with well established cover crop and godelet training system in Espolla (Girona).
Author: IRTA | © Educational use, non-commercial.

diversity and water retention, and reducing soil erosion without negatively affecting productivity. Mature terraced vineyards showed higher levels of organic carbon and nitrogen compared to sloped plantations, with less soil loss from erosion. Newly established vineyards using soil-conserving management techniques exhibited substantial improvements in microbial diversity. The socioeconomic analysis highlighted cost reductions from soil-conserving techniques compared to conventional management. While vineyard altitude entails higher costs, cooperative systems among farmers significantly reduce vineyard management and implementation costs. Creating a shared mountain wine brand or establishing mountain cooperatives are effective measures for cost reduction and income increase.

Enhancing mountain agriculture through vineyard promotion involves scrub area conversion, climate-adapted practices and the promotion of environmental and socioeconomics issues.

/// Always Moving Forward ///

From the results of these experiences, important conclusions emerge regarding the role of livestock farming and forest management in mountainous areas. Sustaining these activities and adapting them according to climate change adaptation criteria are crucial for supplying ecosystem services to society, such as quality water resources.

Therefore, it is essential for community instruments for rural management to also adapt the rules to these necessary adaptive practices to address climate change. Modifying the Pasture Subsidy Coefficients of the CAP to include pastures in wooded areas and also exploring the application of Payment for Environmental Services (PES) is highly recommended. Moreover, climate change necessitates adjusting usual management practices to increase the resilience of agro-silvopastoral ecosystems and maintain adequate levels of animal welfare. In this regard, the presence of pasture under trees in Mediterranean climates is essential for animal welfare during the warmer months, providing shaded areas for shelter.

In recent years, there has been a decline in the economic viability of livestock farming and the number of farmers, despite their crucial role in maintaining forested and pasture lands. High food supplementation costs, coupled with unpredictable sales profitability, have exacerbated this situation, necessitating subsidies and aid to cover essential production costs. Enhancing pasture availability

Recommendations and perspectives to integrate livestock, forestry, and vineyards in Mediterranean mid-mountains.



Vineyards acting as firebreaks. View of Espelt cellar vineyards in Mas Mares (Cap de Creus).
Author: Lluís Regincós, Corps of Firefighters of Catalonia | © Educational use, non-commercial.

for livestock is crucial for mitigating these challenges and improving profitability. Elevating successful local climate change adaptation initiatives to the European policy level, such as through the CAP, is essential. Effective creation of pasture requires comprehensive analyses of forest structure, soil characteristics, and herbaceous species. Regenerative livestock management practices should be promoted, while incentives to reduce the costs of implementing forestry measures for climate change adaptation are advisable.

Vineyards offer a promising opportunity for agricultural diversification, especially in areas heavily reliant on services, tourism, and the tertiary sector. Implementing quality labels linked to climate-resilient landscape management could boost vineyard economic prospects.



Livestock grazing in oak forest from Requesens (Girona).
Author: CREAF | © Educational use, non-commercial.



Pastures restoration in Aragon.
Author: LIFE MIDMACC | © Educational use, non-commercial.

Planning for marketing channels and destinations, such as protected designation of origin or partnerships with local wineries, is advisable. Additionally, supporting vineyard initiatives with robust marketing strategies, like “Mountain wines” or “Fire Wines,” can facilitate widespread adoption of climate change adaptation practices. It is essential to support innovative management strategies, integrate new knowledge, and deploy landscape-friendly infrastructure. Aid for terraces and dry stone structures restoration, crucial for vineyards and biodiversity, can enhance tourism. Encouraging payment for environmental services schemes can drive novel project development. Streamlining bureaucratic processes and prioritizing regions for climate change adaptation efforts are equally vital.

Incentives are needed to reduce the costs of implementing adaptation measures in forestry where benefits are low and costs are high.

Rural exodus leads to dwindling livestock farms, hindering forest and pasture maintenance despite their crucial role.

Moving forward, it is imperative to engage the governments of La Rioja, Aragon, and Catalonia in crafting a unified policy framework aimed at enhancing the sustainable utilization of mid-mountain regions. This collaborative effort should prioritize activities such as raising awareness and building capacity regarding climate change adaptation at both local and regional levels. Simultaneously, support should be extended towards the application and advancement of European policies relating to climate change adaptation within rural mountainous areas.

Vineyards disrupt forest continuity, reducing fire risk and enhancing biodiversity in landscape mosaics.

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- Medidas de adaptación al cambio climático en la media montaña mediterránea: una guía práctica. 2023. URL: https://life-midmacc.eu/es/2023/12/12/entregable-22-medidas-de-adaptacion-al-cambio-climatico-en-la-media-montana-mediterranea-una-guia-practica/ (lin spanish)
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Type of solution: Management Sector: Agriculture
Good practice(s): Soil management, Management alternatives, Community engagement

Building climate resilience in southeastern Spain through the 4 Returns Framework

The AlVelAl association works for the socio-economic and environmental revival of the high Plateau in Southeastern Spain (Granada, Almería and Murcia).



Region in Spain where AlVelAl operates.
Author: AlVelAl | © CC BY



Almond tree in bloom. One of the most important crops in the AlVelAl territory.
Author: Pixabay | © CC BY

/// Context ///

AlVelAl is an association dedicated to the restoration of its local landscape through initiatives like ecosystem rehabilitation, regenerative agriculture, and economic revitalization. This movement underscores the crucial synergy between ecology and economy for the sustainable development of their region, enhancing resilience to climate change and paving the way for future prospects in a thriving rural environment.

Established in 2015 by professionals spanning agriculture, livestock, business, and research, AlVelAl emerged from a shared concern for the socio-economic and cultural challenges faced by the territory – namely rural depopulation, desertification, and the limited economic dynamism in rural areas. This region is also known for being the biggest area worldwide of organic, rain-fed almond tree cultivation.

At present, AlVelAl has over 450 individuals and entities associated, and works across more than 16,500 hectares of land dedicated to organic and regenerative farming. It works in partnership with the Dutch NGO “Commonland”, which works with partners across 20 countries bringing people together to restore degraded landscapes.

/// Solution for a Resilient Future ///

AlVelAl works with the “4 Returns framework”, put forward by the Commonland association. This framework helps guiding stakeholders over time in their collective efforts to restore their territories. The 4 Returns framework links contemporary environmental challenges to degrading landscapes, and it identifies four main losses associated to land degradation: (i) Loss of hope (ii) Loss (or weakened) social networks (iii) Loss of biodiversity and (iv) Loss of economic value. Consequently, a succesful approach to land restoration requires “4 Returns”. Namely (i) Return of inspiration, (ii) Social Returns, (iii) Natural Returns and (iv) Financial Returns.

AlVelAl adapts this framework to the region where they work, and divides it in three main areas or strips, performing different functions: The Natural zone, which main function is ecosystem restoration and biodiversity conservation, the Economic zone, which has a more intensive economic function, and a mixed zone, which is designed to generate an integrated, productive ecosystem through the regeneration of the soil and a sustainable production. They also establish a timeline of 20 years, which is the approximate time that a landscape needs to regenerate.

For the Return of biodiversity, AlVelAl is seeking to create a green corridor of biodiversity in the region where they operate. They join forces with a wide range of actors, both from the public and private sector and they have now restored more than 137 hectares (as per 2021), by planting 140,000 trees and shrubs, sowing 204000 seeds, creating 60 km of hedges and 109 ponds. A specific description of the actions taken in each location may be found in the press kit in their website (https://alvelal.es/PRENSA). All of these actions help to bring back biodiversity, water management, improve the quantity of organic matter and prevent erosion. Altogether, it acts as a mitigation measure of climate change. For the financial returns, they work with different business cases to sell ecological and regenerative products, cultivated in the region. Specifically the promote the “almendrehesa” which combines rain-fed crops of almond trees with production of the Segureño lamb (Protected

Geographical Indication) and aromatic plants. The lamb aerates and fertilises the soil, cuts grass and eats almond shells. For their part, the introduction of aromatic plants contributes to slowing erosion while facilitating insect diversity. As a consequence, the increased number of pollinators act as bridges between the natural and mixed zones, while producing high quality organic honey and derived products (such as pollen, royal jelly and wax).

To promote these activities, AlVelAl advises, supports, dynamises and monitors the implementation of ecological and regenerative agricultural techniques. It delivers training on topics such as landscape restoration, holistic livestock management, the creation of wetlands, contour ditches, the use of biofertilisers and entrepreneurship in the agricultural sector. Financially supporting producers through various economic funds for the implementation of these techniques and supporting the marketing of ecological and regenerative products.



Infographic explaining the Almendrehesa ecosystem (in Spanish).
Author: AlVelAl | © CC BY

/// Always Moving Forward ///

For moving forward, AlVelAl counts with a long-term experimental farm where they cultivate and research with almond trees in Organic and Regenerative Agriculture. The objective of this farm is to validate with results the different Regenerative techniques and agricultural practices the association promotes. It also offers the possibility of sharing knowledge and experiences with professionals from the agri-food and related sectors. The type of experiments developed in this plot are the following:

- Evaluation of the effect of rainfed cover crops on the development of almond trees versus tillage.
- Alternative crops with lavandin and saffron.
- Comparison of different long-term soil management to improve soil fertility.
- Comparison of management with green manure, compost, pellets and pellets, and soil fertility.
- Comparing management with green manure, compost, pellets and tillage.

AlVelAl has also been awarded the Standard for Field Verification of Forest Ecosystem Restoration (Awarded by the consulting company “Preferred by Nature”). This standard provides to land managers a flexible structure to monitor the evolution of their projects, and increase transparency in regards to the evolution of a number of indicators to understand the performance of the project. This Standard is yet another milestone in showcasing the multi-faceted nature of the AlVelAl project, and how their initiative materializes in multiple forms, and in partnership with different actors.

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Acknowledgment / Contribution

Special thanks to Elsa Varela for bringing this initiative to our knowledge. This has allowed us to widen the scope of the best practices showcased.

Authors: Carmen Rodríguez Fernández-Blanco | **Partners:** EFI – European Forest Institute

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Multifunctional management of peri-urban Aleppo pine forests in “Baix Llobregat” mountains (Barcelona)

Design and implementation of silvopastoralism as a climate change adaptation tool within the multifunctional management of Aleppo pine forests.

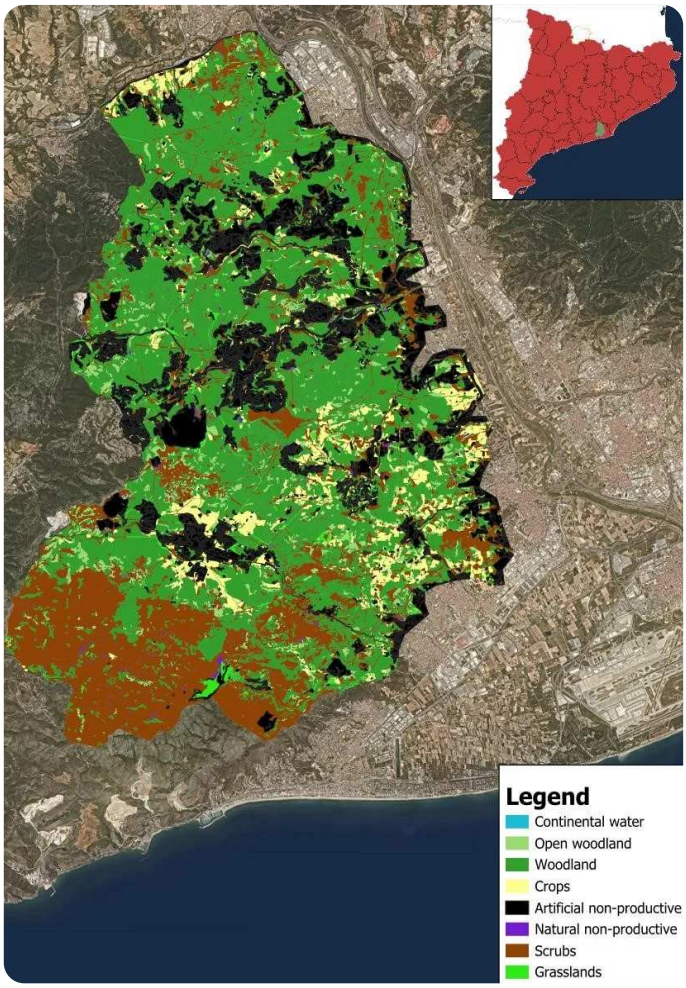


Figure 1. Location of the study area “Muntanyes del Baix Llobregat” and distribution of land uses. | Author: AGS-CTFC | © CC BY 4.0

/// Context ///

Aleppo pine (Pinus halepensis) occurs in most of the (west) Mediterranean basin. In the Iberian Peninsula, it covers 2 million hectares, with a noteworthy expansion since 1970s, when it occupied 0.8 million hectares.

The Baix Llobregat mountains is a 12,000 hectares massif at the south of Barcelona metropolitan area. About 75% of this territory is woodland, most of which result from the spontaneous colonisation of fields and grasslands abandoned since the 1950s-1960s, especially by Aleppo pine. These forests are characterised by a high density of trees and scrub and by a lack of management. Moreover, this heavily anthropized area (300,000 inhabitants) has many urban areas intermingled with forests, which have a strong demand for public use. All in all, the risk of forest fire is very high and its consequences could be dramatic.

Multifunctional forest management of Aleppo pine forests.

The main factor behind this situation is the lack of economic viability of forest management, due to the complex orography, small estate size (most of which belongs to absent private owners) and low-quality products. The lack of economic viability hampers implementing multifunctional forest management, which should focus on:

- **Prevention of large forest fires:** promoting forest structures with low vulnerability to fire in Strategic Management Points (SMPs), i.e. the areas where a reduction in fuel would contribute significantly to the prevention of fires on a massif-wide scale.
- **Wood production:** wood is, at present, the main product that could help finance multifunctional forest management. At present, the main uses are energy (biomass) and small sawn wood.
- **Other ecosystem services:** the diversity of these forests allows hosting biodiversity values, public use, landscape values and non-timber forest products including pastures, resin, mushrooms or aromatic, medicinal and ornamental plants.

In this factsheet we describe the transformation of the abandoned forest of Can Colomer into a managed silvopastoral system to, simultaneously, improve forest vitality and drought resistance, reduce wildfire vulnerability and generate local bioeconomy resources.

In terms of area, Aleppo pine (Pinus halepensis) is the second main tree species in Spain, showing a remarkable expansion in the last decades, especially after land abandonment and wildfires.



Figure 2. Herd of donkeys grazing in the intervened areas.
Author: AMB | © CC BY 4.0

The main threat for these forests is the vicious circle of abandonment, low economic viability and vulnerability to wildfires. Silvopastoralism could be part of the solution.

/// Solution for a Resilient Future ///

As part of the LIFE AgroForAdapt project (https://agroforadapt.eu/en/home-eng), we have defined and implemented various silvicultural treatments and installed support infrastructure to enable these areas to be maintained with low vulnerability to fire by means of herds of goats and donkeys. The intervention area is 58 hectares. The actors involved are AMB (promoter), Baix Llobregat County Council (forest owner) and CTFC (technical coordinator).

These interventions have a number of simultaneous objectives:

- Reducing the vulnerability of the forests to large fires by reducing the biomass load and creating vertical and horizontal discontinuities, thus creating a structure that is more attractive for the activation of silvopastoralism and that can subsequently be maintained by livestock.
- Increasing forest vitality and reducing vulnerability to drought, pests and diseases by reducing tree density in favour of the most vital trees and shrub cover in favour of less fire-prone species, thus increasing the availability of resources (water, light, nutrients) per individual.
- Increasing the production of fresh water and recharging aquifers by reducing the density (and therefore transpiration) of tree and shrub layers, thus improving the water balance.
- Diversification of uses and income sources.
- Creation of ecotones and diversification of habitats, increasing the land's capacity to support biodiversity.

Parameters	Pre-Intervention	Post-Intervention
Density (tree/ha)	2.769	1.337
Basal area (m2/ha)	22,5	12,4
Canopy cover (%)	>70	50-60
Average diameter (cm)	10,2	10,9
Undergrowth cover (%)	>70	< 25
Rothermel fuel model	4	11
Vulnerability to crown fires (Piqué et al, 2011)	A1	B15

Figure 3. Description of the silvicultural intervention in the stand.
Author: AGS-CTFC | © CC BY 4.0



Figure 4. Location of the demonstration stands. Yellow: intermediate intensity thinning; Green: heavy thinning. | Author: LIFE AgroForAdapt | © CC BY 4.0

Implementation of extensive silvopastoral systems at Can Colomer

- Increasing the growth and timber quality of the promoted trees, which may provide higher value wood products in the future.

The 58-hectare demonstration stand consists of various pure and mixed formations of Aleppo pine (Pinus halepensis) and occasional holm oak (Quercus ilex).

The main physical and climatic characteristics of these forests are:

- Average altitude: 470 m
- Average slope: 40%
- Orientation: North (54 hectares), South (4 hectares)
- Physiographic position: Hillside (95%) and valley floor (5%)
- Climate classification (Papadakis): Mediterranean maritime
- Annual mean temperature [coldest month; hottest month] 16.2ºC [9.3ºC; 23.8ºC].
- Annual rainfall [summer rainfall]: 604 mm [120 mm].

The silvicultural interventions includes treatments in the tree and understorey layers:

- **Tree layer:** selective thinning, reducing density and basal area by almost 50%, while maintaining a canopy



igure 5. Silvicultural treatments in Can Colomer estate.
Author: LIFE AgroForAdapt | © CC BY 4.0

cover of around 60% to preserve the forest microclimate. The retained trees are pruned to a height of 2 m and the resulting debris is removed. The criterion for selective thinning is to promote trees that are: i) vital; ii) of underrepresented species; iii) particularly well-formed; and/or iv) host microhabitats relevant to biodiversity.

- **Understorey layer:** the understorey intervention consists of selective scrub clearance, reducing the understorey cover to 20-25%. This will facilitate the movement of herds in the forest, reduce the transpiration and competence caused by shrubs and maintain them as a forage resource. The criterion of selective clearing is to maintain all species, while favouring the least fire-prone and fodder-valuable or biodiversity-interesting species. Debris is crushed in situ.

In 8 hectares of gentle slope, divided into 2 plots of 4 hectares each, the forest has been cleared with a much more intensive thinning (canopy cover reduced to 30%) to transform the landscape into an open woodland (dehesa-like), where pastoralism will be the predominant use. This area acts both as a very low vulnerability area and as a source of grass fodder production, which will make the silvopastoral management more viable by combining woody and herbaceous resources.

The proposed grazing management foresees 4 annual entries, combining open areas dominated by grassland and forest silvopastoralism. The planned stocking rate is 0.3 livestock units/hectare/year. The mixed herd of goats and donkeys is owned by a social cooperative in Sant Climent de Llobregat. The auxiliary infrastructure will allow the herds to be fenced in and stay overnight.

The forest structure achieved will be maintained with the support of silvopastoralism with herds of goats and donkeys. In LIFE AgroForAdapt we will assess its effect on multiple ecosystem services.

We have conducted a silvicultural treatment consisting on selective thinning and shrub clearing to reduce fuel load and its continuity, to increase tree vitality and reduce wildfire vulnerability.

/// Always Moving Forward ///

The multifunctional management of the Aleppo pine forests presented here aims to reverse land abandonment and promote a resilient landscape.

One of the main problems in the Muntanyes del Baix area is the lack of activity in the primary sectors (agriculture, livestock farming, forestry), which results in:

- A sharp interface between abandoned, dense forests and a highly urbanised landscape, which means both a higher risk of ignition and a greater threat to human life and infrastructure in the event of a forest fire.
- Property ownership is generally disconnected from the territory and its activities. Any collective action (i.e. joint forest management) is limited by the challenge of identifying and contacting the owners of small plots of forest.
- The forests resulting from the spontaneous colonisation of open areas since the middle of the XX century are predominantly young, unproductive and unmanaged, with low vitality and a high risk of fire.

These conditions make it economically unfeasible for landowners to implement sustainable forest management without support from public administrations. The major challenges are therefore to identify, mobilise and raise awareness among landowners on the need to manage their forests, and to secure economic resources to enable their multifunctional management. An important argument that should facilitate the mobilisation of the necessary resources is the civil protection aspect, given the threat to local communities.

In the case of silvopastoralism, a major challenge is the shortage of shepherds and the difficulty of establishing new herds without an adequate network of infrastructure, both for the animals (tanks, troughs, etc.) and for the shepherds' accommodation. It is therefore essential that several public and private actors work together to promote and strengthen the forestry and livestock sectors in order to achieve the economic, environmental and social benefits of silvopastoralism, in addition to protecting the population from forest fires.

In order to assess and transfer these benefits, the LIFE AgroForAdapt project has developed a protocol for monitoring silvopastoral systems in Mediterranean

Silvopastoralism: a complex technical and socioeconomic challenge



Figure 6. Permanent monitoring plot, with light, temperature and moisture sensors and with exclusion cages to follow the evolution of forage production.
Author: AGS-CTFC | © CC BY 4.0

forests, including 4 types of monitoring: i) silvo-dasometric characterisation, fire vulnerability and grazing potential; ii) carbon balance; iii) long-term production and economic assessment; iv) assessment of microclimate and water balance.

In addition, in 2024 we are developing the tool "PrioSilPas" (Prioritisation of Silvopastoral systems for forest fires prevention), a tool that aims to identify forest areas where silvopastoral systems would be particularly strategic to achieve and maintain a landscape with low vulnerability to large forest fires. This tool consists of two sub-tools: i) Critical areas for fire management: landscape classification from a fire ecology and fire suppression perspective; ii) Feasibility of

The working area combines a landscape with high vulnerability to wildfires (continuous and overdense forests) and a remarkable urban development, combined in a dangerous interface.

The use of silvopastoralism as a tool to support forest management makes it necessary to reach agreements between multiple public and private stakeholders.

silvopastoralism: landscape classification according to the technical and economic viability of silvopastoralism. The land is classified at a scale of 1:25,000, giving maximum priority to areas that are most critical from a fire management perspective and where silvopastoralism is more feasible. The tool is expected to be available in autumn 2024.

Other innovations that could facilitate silvopastoral activities are the adoption of collective forest management instruments and infrastructures and equipment for shepherds, such as collective meat processing facilities, mobile slaughterhouses, GPS collars and virtual fences, as well as marketing actions such as the valorisation of silvopastoral products in local markets, restaurants and hotels.



Figure 7. Marking of silvicultural treatments by CTFC technicians.
Author: AGS-CTFC | © CC BY 4.0

Further information

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Eco-hydrological silviculture for climate change adaptation in Moianès county (Barcelona)

Designing a multifunctional silviculture incorporating the production of blue water and other ecosystem services.

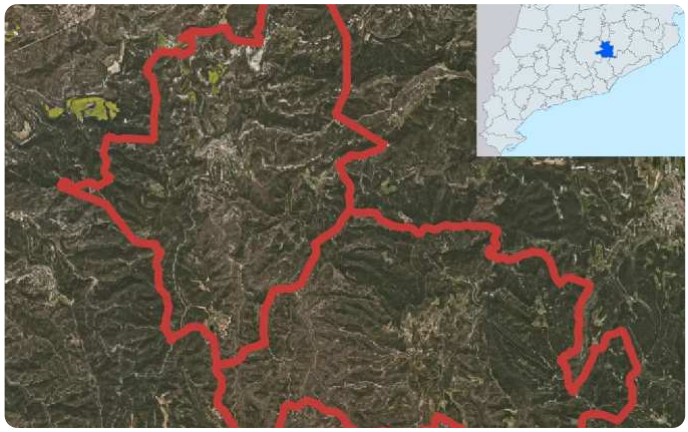


Figure 1. The study area (Monistrol de Calders and Granera), in the Moianès region and partially included in the Sant Llorenç del Munt i l'Obac Natural Park.
Author: AGS-CTFC on the ortofoto of ICGC | © CC BY 4.0



Figure 2. Riera de Sant Joan at Molí d'en Sala in March 2022 (Monistrol de Calders).
Author: AGS-CTFC | © CC BY 4.0

/// Context ///

Forests provide a wide range of ecosystem services, the provision of which depends on climatic, edaphic and forest structure factors. Multifunctional forest management makes it possible to adjust the relative weight of each ecosystem service, thus optimising the overall management outcome according to societal needs and the specific context of the forest. An increasingly important ecosystem service in the Mediterranean basin is the regulation of the hydrological cycle, which affects (and is affected by) the structure of the forest (canopy cover, species composition, density, life stage, etc.), with very complex relationships with other factors such as climate regime, soil, relief, prevailing winds, etc. This service has a direct impact on the availability of blue water, i.e. the amount of water available for human consumption.

Green infrastructure is the whole of the network of natural and semi-natural areas that are planned and managed with the aim of providing a maximum of services to people. The improvement of this infrastructure consists of a set of actions aimed at maintaining a stable natural environment in a good state of conservation and contributing to the diversification, enhancement and optimisation of the provision of ecosystem services.

Forest management aimed at the generation of fresh water and other ecosystem services.

Silviculture can increase the forest ecosystem service of water supply and aquifer recharge in Mediterranean areas, especially in upper catchments and dense forests.

The study of ecosystem services carried out in 2022-23 by the Forest Science and Technology Centre of Catalonia (CTFC), at the request of the Department of Infrastructure and Natural Spaces of the Barcelona Provincial Council (DIBA), aimed to develop scenarios for adaptation to climate change and simulate their impact on ecosystem services in the medium and long term. These models are based on an analysis of the recent past, the current situation and projections of expected future developments. These analyses and models incorporate multiple climate, soil and forest structure data and projections and are site-specific. With this methodology it is possible to study how different land management models affect ecosystem services, in particular by focusing on the comparison between the no-action scenario and a multifunctional forest management approach.

Combine soil, forest structure and historical weather data with modelled climate projections to assess the effect on the water balance of applying vs. not applying sustainable forest management.

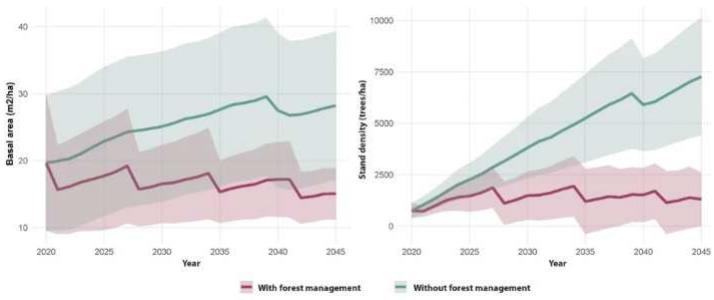


Figure 3. Comparison of basal area and forest density modelling results of the study area in a scenario with (red) and without (green) forest management.
Author: AGS-CTFC | © CC BY 4.0

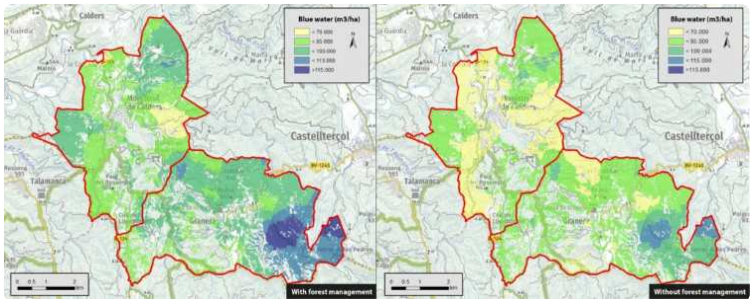


Figure 4: Modelling results of the volume of blue water generated under a scenario with and without forest management for the period 2020-2045.
Author: AGS-CTFC | © CC BY 4.0

/// Solution for a Resilient Future ///

The study area covered the municipalities of Monistrol de Calders and Granera, in the county of Moianès (inland Barcelona province), and covers an area of 4,580 hectares, of which 93% is woodland: 3,000 hectares of forest and 1,100 hectares of scrub and sparse forest (ICGC, 2018). The altitude is between 500-900 m and the area is characterised by a Mediterranean-continental climate. The dominant forest species are Aleppo pine (*Pinus halepensis*), Scots pine (*Pinus sylvestris*), black pine (*Pinus nigra*) and pedunculate oak (Quercus pubescens). In recent years there have been increasing problems of spring drying and groundwater abstraction in the area.

The aim of this study was to investigate the impact of forest management practices on the provision of various ecosystem services, with particular emphasis on freshwater provision.

Past weather and expected climate projections were obtained with the spatialisation models meteospain (Granda et al., 2021) and meteoland (De Cáceres et al., 2018). The spatial projection of climate change is simulated with meteoland for the period 2040-2050, compared to the measured period 2012-2020. This model predicts an overall temperature increase of between 0.8 and 1.3°C and changes in the precipitation regime, with an expected decrease of up to 20% in the southern part of the area and an increase of 25% in the northern part of the area. In order to characterise the past and present vegetation of the study area, we studied the plots of the Spanish National Forest Inventory (IFN) within the area and the inventories carried out in the Forest Management Instruments (FMI) in force in 2020, which cover more than 70% of the work area.

In total, more than 300 inventory points were available. The composition of the forest cover was completed with the

Study of ecosystem services in the municipalities of Granera and Monistrol de Calders.

In our study region we calculate that eco-hydrological silviculture can increase blue water by 25% in average or slightly wet years. However, in dry or very wet years the effect is not significant.

Spanish Forest Map (MFE25, 2016) in the areas where FMIs are not available. The vegetation analysis was carried out with the ecophysiological model medfate 2.3.7 (De Cáceres et al., 2015; 2021), which incorporates soil data from the SoilGrids project (Hengl et al., 2017). The expected future (2020-2045) changes in forest structure were simulated using the medfate model, with two scenarios: i) one considering the application of sustainable forest management, and ii) one considering the abandonment of these forests (no management). The forest management model consists of selective thinning (30% of the basal area) applied when the stand exceeds 18 m2/ha of basal area, with a minimum of 7 years between two successive interventions and only taking into account the area included in the FMIs (70% of the area).

Using this methodology, we linked climate, soil and forest structure data to simulate the ecophysiological processes relevant to the functioning of the forest ecosystem, particularly those related to hydrology: water recharge, soil drainage and surface runoff. The simulations carried out showed that forest management leads to an overall increase in freshwater production, although the effect depends on the year. The increase is particularly significant in average or slightly wet years, with an increase in freshwater production of around 25%. In dry or extremely wet years, however, the effect of forest management is not significant.

In addition to increasing blue water, eco-hydrological silviculture can improve forest vitality and significantly reduce the forest vulnerability to drought.

Furthermore, the effect of forest management on tree water stress is important: it reduces the number of annual days leading to tree water stress, defined as days when the probability of physiological death of the dominant species is greater than 50%. This reduction is particularly remarkable in the most drought-prone areas (those occupied by water-demanding species and/or with a relief and soil that hinder the ability to retain moisture), which go from 50 days of water stress per year (no management scenario) to around 20 (sustainable forest management scenario).
It is important to value eco-hydrological forest management especially when we are facing these climate change scenarios.

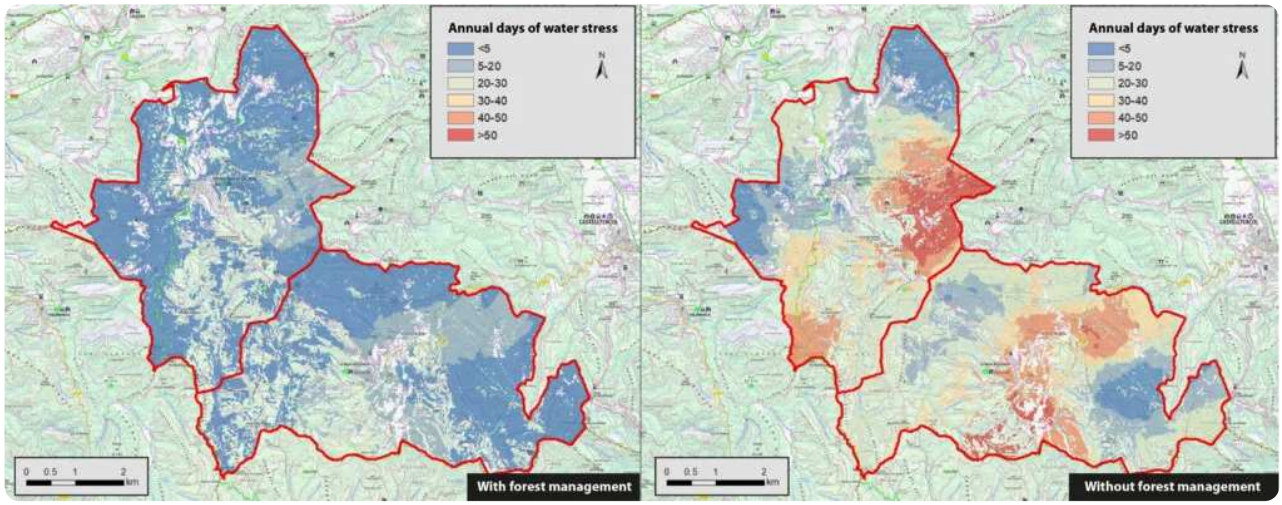


Figure 5. Modelling results of the average number of annual days of forest water stress under scenarios with and without forest management (2020-2045).
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/// Always Moving Forward ///

Combining field data with GIS tools and physiological, climate and soil models allowed us to:

- develop detailed maps of the areas most vulnerable to the main risks and impacts of climate change
- simulate the effects of different landscape management alternatives.

In this way, based on empirical information and the best available models, we could plan where and how to intervene, anticipating possible impacts while providing relevant information for prioritising actions to adapt to the impacts of climate change on forests and the ecosystem services they provide.

Forests play a key role in several ecosystem services, including hydrological processes, as they regulate runoff and infiltration, influence mesoclimate at the catchment scale, and release water to the atmosphere through evapotranspiration. Other important services included in the modelling, but not presented in this factsheet due to space limitations, are carbon sequestration, vulnerability to forest fires and ecological resilience.

Modelling tools, forest management operations and landscape planning: a necessary alliance.

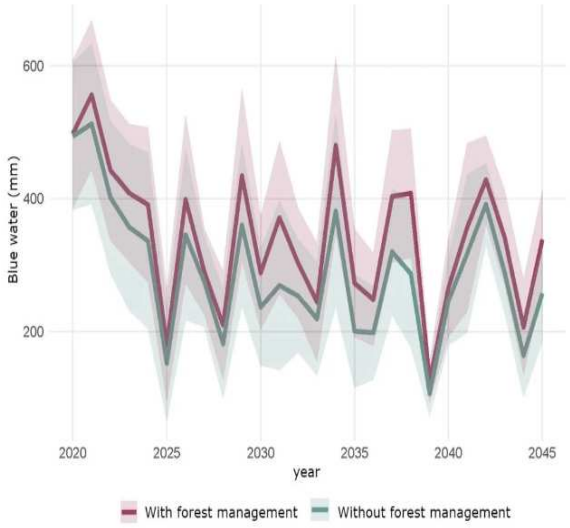


Figure 6. Annual blue water production in the study area, with a scenario with (red) and without (green) forest management, for the period 2020-2045.
Author: AGS-CTFC | © CC BY 4.0

All these ecosystem services can be improved through modelled forest management.

In order to develop good models, it is essential to obtain as much relevant and reliable data as possible within the study area to select the most appropriate parameters and develop the most accurate models.



Figure 7. Area affected by the 2003 fire and its state in year 2021 (Monistrol de Calders).
Author: AGS-CTFC | ©CC BY 4.0

This is a limitation of this methodology in areas where limited information is available. In our study, a key factor was the availability of forest management instruments in place in a large part of the study area, resulting in accurate and site-specific data on forest structure. Operational planning at the farm level is key to forest management actions: assessment, monitoring, planning and implementation of silvicultural measures, certification and financing.

Land planners, field practitioners, owners and researchers need each other to achieve more resilient and viable landscapes.

Always aware of their limitations, models can effectively support decision-making at both farm and landscape level, provided they are based on accurate empirical data.

In this way, the interaction of forest management and modelling with strategic landscape planning is bidirectional. On the one hand, the tools at the farm level were prepared with detailed information that can be included in the analysis at the landscape level, from which the strategic guidelines are developed, integrated with the rest of the analysed information. On the other hand, the lines of action and the zoning of priorities of the landscape strategic approach were transferred to the operational farm planning to be finally implemented.

The empirical studies linking the complex relationships between forest structure, water balance and soil characteristics are difficult to carry out due to the large experimental and demonstration area required and the complexity of the equipment needed (surface and subsurface flow measuring stations), so modelling offers a cost-effective solution to support decision-making. It should also be noted that for complex systems such as forests, it is necessary to continue to generate empirical data to improve these models. Projections can also be affected by unpredictable disturbances such as fires, severe storms or pest outbreaks. For example, a 1,800 hectares fire affected this study area in 2003, with significant effects on vegetation structure and soil properties.

This study paved the way for the application of this methodology in other areas, as the models used are publicly available. Furthermore, this analysis can be complemented by optimisation studies, where we could explore the impact of different forest management approaches (variations of the one proposed) on the provision of different ecosystem services.

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ResAlliance

Type of solution: Management Sector: Forestry

Good practice(s): Water management, Soil management, Management alternatives, Protection against biotic and abiotic hazards

Restoration of degraded areas for flood risk mitigation

The Greek Forest Service have been successfully restoring degraded areas, to mitigate the risk of flooding and the damages caused by hundreds of torrents across the country.



The location of Metsovo in Greece and the restoration project area.
Author: Gavriil Xanthopoulos – Annotation on Google Maps & Google Earth images
© Google Maps & Google Earth



A 1960 photo showing the extremely poor condition of the Metsovitikos catchment.
Author: Greek Forest Service | © Greek Forest Service

/// Context ///

In the steep terrain of many mountainous areas of Greece, the combination of heavy overgrazing with repeated fires (especially during the 2nd World War and the civil war that followed) led to loss of forest vegetation and soil. As a result, in the 1950s, it became evident that hundreds of torrents across the country were causing flooding on a regular basis, destroying agricultural areas in the plains and damaging settlements. At that time the Greek Forest Service (GFS) undertook the task to restore many water catchments where such torrents originated through soil retention measures, including reforestation, and creation of water flow control infrastructure. Many such projects were executed in the following decades with impressive results, substantially mitigating the flooding damage problems.

An example of the restoration projects carried out by the GFS was the one aiming at the heavily degraded catchment area of the Metsovitikos torrent, near the town of Metsovo, on the Pindos mountain range. The total area of the catchment is 2696 hectares, elevation ranges from 720 to 1830 m and the average yearly rainfall is 1400-1550 mm. In 1955, a comprehensive project was initiated, constructing over 1000 check-dams, 70 gabions walls, and numerous other phytotechnical works, followed by reforestation with 1.8 million seedlings in over 500 hectares. The project's success and its results are evident today, showcasing its environmental value in preventing erosion, fostering vegetation growth, mitigating flooding and associated damages. In light of the climate crisis, such programs are crucial to counter desertification, particularly in the Mediterranean region.

Restoration projects in degraded mountainous water catchments by the Greek Forest Service (GFS) offer valuable examples of revegetation, water retention and flood mitigation.

Unfortunately, in the 1990's priorities and funding for the GFS changed, and by the beginning of the 2000's such efforts were abandoned. Furthermore, there was no provision for maintenance of the works that had been completed. The Mediterranean tropical-like cyclones that occur in the last few years with increased frequency, bringing storms such as "Ianos" in September 2020, "Daniel" and "Elias" in September 2023 that poured extreme amounts of rain in a short time and resulted in unprecedented flooding in the central part of Greece, brought in mind the value of those restoration works on Pindos, the mountainous backbone of the country.

Restoration projects in degraded water catchments by the Greek Forest Service offer valuable example.

Destructive flooding in central Greece in the last few years, linked to climate change, shows how short-sighted has been the abandonment of the restoration projects by the GFS.

/// Solution for a Resilient Future ///

Soil erosion has negative impacts on fertile soil and natural habitats. Its intensity is influenced by factors like lithology, slope, erosive forces (e.g., rainfall), and the presence of protective vegetation. In steep mountainous terrain, lack of vegetation results in unobstructed flow of rain water, increased erosion, and ultimately the development of torrents that carry silt, rocks and other materials to the plains, resulting in flooding and causing damages. Greece is a mountainous country, with many tall mountains skirted by small plains around their base. The historical heavy use of vegetation for grazing by sheep and goats, often combined with the use of fire by shepherds, resulted in large areas denuded of plant cover and the development of many damaging torrents across the country. The situation became worse with repeated fires during the 2nd World War and the civil war that followed.

In the 1950s, it became evident that hundreds of torrents across the country were causing flooding on a regular basis, destroying agricultural areas in the plains and damaging settlements. This created the need for damage mitigation works in mountains and in the plains. The Greek Forest Service (GFS) undertook the task to restore selected mountainous water catchments where such torrents originated, through soil retention measures, including reforestation, and creation of water flow control infrastructure.

One of the restoration projects carried out by the GFS focused on Metsovitikos torrent, near the town of Metsovo, on the Pindos mountain range which has a catchment area of 2696 hectares. Elevation ranges from 720 to 1830 m and the average yearly rainfall is 1400-1550 mm. The slopes are very steep and in the 1950s the catchment was heavily degraded. Erosion was exacerbated due to unstable flysch deposits, sparse forest cover, steep slopes, intense rainfall, logging, and grazing, causing landslides that threatened nearby settlements and infrastructure. In 1955, a comprehensive restoration project was conceived and planning started. The final plan was approved in 1960 and works were initiated, constructing over 1000 check-dams, 70 gabions, and numerous other phytotechnical works, followed by reforestation with 1.8 million seedlings in over 500 hectares.



A 1960 photo showing a series of water flow control dams. A proudly standing forest guard on the dam shows the scale.
Author: Greek Forest Service | © Greek Forest Service

Heavy use of vegetation for grazing, often combined with the use of fire by shepherds, resulted in large areas denuded of plant cover and the development of many damaging torrents across Greece.

By the 1980s there was clear evidence of improvement. Vegetation cover had increased substantially. Water retention had increased, water outflow peaks had been reduced and downstream flooding had been mitigated. A series of photos in 1960 documented the degraded condition at the time the works were being constructed. The same places were revisited and photographed in the 1980s illustrating the tremendous improvement. A scientific study published in 2004, evaluated the effectiveness of the project and verified the reduction of the destructive phenomena. The study also recognized the limitations of phytotechnical works regarding complete protection.

In retrospect, this project was carried-out successfully due to the heavy manual work invested by the local population who were employed as workers by the GFS, and the GFS foresters and other personnel who planned the activities and oversaw their application, in steep terrain and under very demanding conditions. The need for employment was only one side of the availability and performance of those workers. The stamina of all those people, temporary workers and GFS employees, but also the pride for their achievement, as evidenced in multiple photographs, were also remarkable.

A demanding restoration project of a heavily degraded area in the Metsovitikos torrent watershed on Pindos mountain.

One of the restoration projects carried out by the GFS focused on Metsovitikos torrent, near the town of Metsovo, on the Pindos mountain range.



A 1985 photo of the same series of dams. The same forest guard, from the previous photo, on the same dam.
Author: Greek Forest Service | © Greek Forest Service

Works were initiated in 1960, constructing over 1000 check-dams, 70 gabions, and numerous other phytotechnical works, followed by reforestation with 1.8 million seedlings in over 500 hectares.

Unfortunately, according to a later report of the Forest Service office in Metsovo, the project was completed to about 90% of what was originally planned.
Most important, with dwindling funding for the Forest Service from 2000 on, little if any maintenance was carried out, as a follow-up. The same happened in many other places in Greece where similar projects had been executed.

/// Always Moving Forward ///

The experience of the Metsovitikos restoration effort and other similar projects in Greece, has illustrated beyond any doubt the effectiveness of the type of activities that were carried out. The project's success and its results are evident today, showcasing its environmental value in preventing erosion, fostering vegetation growth, mitigating flooding and associated damages.
Furthermore, such programs are crucial to counter desertification, particularly in the Mediterranean region. Unfortunately, the abandonment of further works of this type and the lack of a maintenance program, gradually led to loss of the expertise that had been developed within the GFS, ranging from the temporary workers and the forest guards to the local foresters and the head unit at the GFS headquarters in Athens. All this at a time that the "bells are ringing" as the climate is modified.

Climate change, by increasing temperature increases the amount of water vapor in the air due to more evaporation from water bodies but also maintains relative humidity below saturation since warmer air can hold more water vapor before it is saturated. On one hand, this leads to lack of rainfall and drought, but when the air cools suddenly (e.g. with a passage of a cold front) the amount of vapor that condenses can result in rainfall much like the one experienced in the tropics. There are signs that this is already happening. The Mediterranean tropical-like cyclones that occur in the last few years with increased frequency, bringing storms such as "Ianos" in September 2020, "Daniel" and "Elias" in September 2023, in Greece,

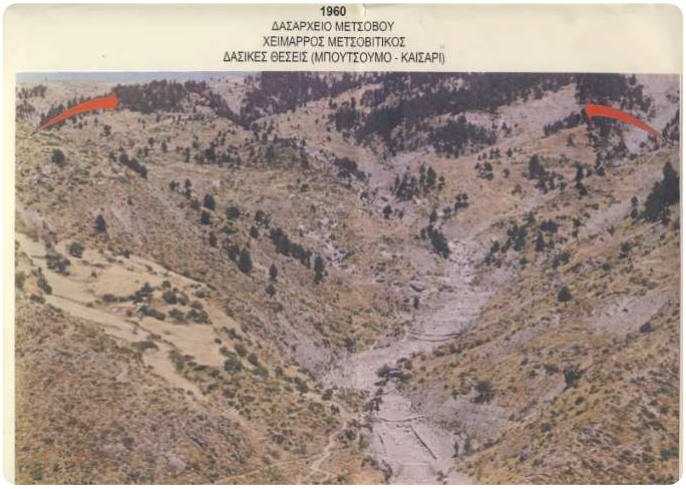
Restoration projects such as the Metsovitikos one should be restarted in view of the challenges of climate change.

The Metsovitikos restoration effort and other similar projects in Greece, illustrated beyond any doubt the effectiveness of the type of activities that were carried out.

that poured extreme amounts of rain in a short time and resulted in unprecedented flooding in the central part of Greece have rung a warning bell. Whereas, after the disaster, big technical companies are planning large scale dams and other water management projects in the plains of Thessaly, the proven value of the restoration projects in the mountains should be kept in mind and they should be revisited. Smoothing water flow peaks in the mountains and retaining significant amounts there, can contribute substantially to avoidance of future disasters in the plains.



Small dams and reforestation on rugged terrain in 1960 (left) and the results observed in 1985 (right).
Author: Greek Forest Service | © Greek Forest Service



Part of the Metsovitikos watershed in 1960.
Author: Greek Forest Service | ©Greek Forest Service

Currently, documentation of these time-honored techniques is publicized in Greece and across the Mediterranean with projects such as ResAlliance, hoping to contribute towards the development of timely restoration initiatives before flooding disasters become even worse. The expertise will have to be redeveloped, personnel will have to be trained and methods may have to be modified to make use of new knowledge, techniques and equipment and probably to cater to new needs. For example, as the forest fire problem is worsening and is expanding to areas previously thought as immune, such as the high-elevation forests, it might make sense to create taller dams and develop small lakes in appropriately located places. These lakes could be available for water pick-up by firefighting helicopters in case of fire, in addition to serving for holding peak water flows in case of heavy rains. Such initiatives could achieve both effectiveness and efficiency. A series of restoration demonstration projects across the Mediterranean, similar to the Metsovitikos one, with funding from a European source such as LIFE+ or INTERREG, could be the solution for the reintroduction of these techniques. However, any such effort should be accompanied by a long-term monitoring effort to gauge effectiveness and propose refinements, if needed.

Following the flooding disastsrs in central Greece the proven value of the restoration projects in the mountains should be kept in mind and they should be revisited.

A series of restoration demonstration projects across the Mediterranean funded by programs such as LIFE+ or INTERREG, could be the solution for the reintroduction of these techniques.



The same part of the Metsovitikos watershed in 1982.
Author: Greek Forest Service | ©Greek Forest Service

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Chapter 3

Social / Communities Practices

Building resilience requires new ways of bridging people, knowledge, and new ideas. Social and digital practices establish ways so that innovations can rapidly diffuse and whole communities can find the tools they require to respond to adversity together.

In the digital practices approached in this chapter, digital platforms allow landowners and organizations to share information, exchange knowledge, and work on a massive scale for a common objective. From advanced techniques to mapping wildfire risk or organize wildfire prevention, to online platform to certificate forest products and ecosystem services, these innovations combine the international digital networks with landscape resilience.

On the social practices, the cooperation between civil society organizations and communities allow to build trust relations between multiple parties, leading to raise awareness, educate the public, and encourage the populations to participate in resilience-related initiatives. Campaigns, workshops, and even serious games enable individuals to grasp the risks and possibilities, and to feel a sense of collective responsibility. Such practices have the power the gather large groups of people with common goals, providing them with a voice to participate in the future of their landscapes.

Together, digital and social innovations remind us that resilience is not only about the land but also about communities. These practices help to create networks of informed, active, and engaged citizens for building landscape resilience.

Wildfire Preparedness Day: Risk Awareness for Wildland Urban Interface Communities

The international Wildfire Preparedness Day fosters the engagement of communities to be prepared for the wildfires season. This case study was implemented in the town of El Bruc, in Catalonia (north-east Spain).



All actors involved in the Preparedness Day in El Bruc, 2021.
Author: Pau Costa Foundation | © CC BY-NC-ND 4.0



Explaining to a neighbor of El Bruc the key messages to be self-protected in case of a wildfire occurs. | Author: Pau Costa Foundation | © CC BY-NC-ND 4.0

/// Context ///

In Catalonia, wildfire risk has worsened due to rural abandonment, leading to wild vegetation growth, and climate change, causing longer, stronger heatwaves and droughts. Combined with urban expansion into forests, these factors heighten civil protection challenges against wildfires.

Wildfire Preparedness Day is an international day that was originated in the USA by the National Fire Protection Association through the Firewise USA® program. It is usually celebrated worldwide on the first weekend of May and seeks to communicate the problem of wildfires in wildland urban interface (WUI) areas.

The impacts achieved through the Wildfire Preparedness Day:

- Increase self-protection capabilities at homeowner and community levels.
- Anticipate and manage wildfire threats on industrial sites and infrastructure located at the WUI.
- Increasing risk awareness among WUI residents.
- Capacity-building, collaboration, and knowledge-sharing among stakeholders involved in communities protection.
- A coordinated and integrated approach to wildfire risk resilience.

Preparedness Days began to be held in Europe in 2018 in places such as Catalonia and Madrid (Spain), and Tuscany (Italy). In Catalonia, the Preparedness Day has been implemented in three towns: Vacarisses (2018), Begur (2019) and El Bruc (2021).

/// Solution for a Resilient Future ///

Community awareness is considered a crucial aspect considering the population exposed as a proactive stakeholder in fire risk reduction strategies. That is why the pilot case served to adapt the successful participation approaches developed in other countries (for example, Firewise USA® in the United States), to the regional study conditions.

The actions to be carried out during the Preparedness Day can be very varied:

- Door to door to explain the risk of fire and measures to consider.
- Informative talks.
- Field visits.
- Environmental education activities for children.
- Tastings of local products that promote landscape management, etc.

In short, it is about involving the population to end up encouraging them to take self-protection measures. In the case of El Bruc, the door-to-door methodology was adopted for its ability to reach people directly exposed to risk. This activity took place on October 27th, 2021, in the urbanization of Montserrat Parc, an urbanized area very exposed to the risk of fire, particularly those that are reinforced by the dry and warm winds of the west.

To carry out the door to door, we had the collaboration of different emergency management bodies of Catalonia

and other entities involved in risk management: the Fire and Rescue Service, Civil Protection, Barcelona Provintial Council and the Police Service. Four mixed groups (mix of organizations) were formed with the aim of seeking interaction and impact on neighbors. Each group had a number of streets assigned to avoid duplications and houses without getting there. Before starting, an initial briefing was held to agree on key messages and distribute the communicative material, with the main objective of understanding the fire risk of the municipality and simple self-protection measures.

For approximately two and a half hours, the different teams were distributed through the urbanization to inform about the measures of prevention of forest fires and preparation that the neighbors must carry out in their home and in the surroundings of the urbanization. Residents were advised that El Bruc is in a particularly high-risk zone, and that, despite the fire season is on summer, there may be fires any time of the year if the appropriate conditions occur. Printed information was delivered to the neighbors so that they can consult it.

In total, almost 300 houses were reached, to which 35% could be established conversation. At 65% where no one was there, the information material was also left in the mailbox. In general, the residents of the urbanization showed a high awareness of the problem of forest fires. A fairly common comment that stood out above the rest was the memory of the large wildfires that has suffered the urbanization, mainly Montserrat 1984 and Òdena 2015. The first hit Montserrat Parc, but after more than 35 years, many residents did not remember it or did not have it in mind. By contrast, the recent fire of 2015 did have a great impact on the population that still lingers. Many of the residents saw the flames nearby and had to be evacuated, even though the fire eventually took another direction and did not impact on Montserrat Parc.



Brochure delivered to neighbors – front page.
Author: Pau Costa Foundation | © CC BY-NC-ND 4.0



Brochure delivered to neighbors – back page.
Author: Pau Costa Foundation | © CC BY-NC-ND 4.0

/// Always Moving Forward ///

The lessons learned extracted form the Preparedness Day in El Bruc town:

- It is recommended to implement the Preparedness Day with a bottom-up prespective, taking advantage of the social fabric of the community.
- It is important that the neighbors have experienced a previous wildfire to be aware of their exposure to risk and to be more receptive to messages.
- It is necessary to follow up the community after the activity and continue implementing awareness strategies in order to guarantee that the households comply with the preparedness measures.
- The fact of doing the activity in a community of first residences is considered positive in order to be able to follow up on it in the future. Doing the same activity in second residences and touristic areas would hinder the dissemination and rooting of the message.
- The messages must be simple and in a positive tone to reach residents more easily. The materials to be distributed must be attractive and have a relevant impact on the citizens.
- It is necessary to create an European framework to define common strategies to scale the implementation of the Preparedness Day in other countries.

Further information

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The new generation MeFiTu: Mediterranean forests, fire, and you

Increasing the knowledge of students about wildfire Risk Awareness and self-protection.



Figure 1: Awarning to primary school students in Catalonia.
Author: Pau Costa Foundation | © CC by Pau Costa Foundation



Figure 2: Cooperation with the Fire Service Extintion from Catalonia to engage the students.
Author: Pau Costa Foundation | © CC by Pau Costa Foundation

/// Context ///

Mefitu is an educational initiative focusing on forest fire ecology in the Mediterranean Basin, for primary and secondary school students (Figure 1). It aims to inform, engage, and instill awareness about the role of fires in ecosystems, urging a shift from perceiving them solely as destructive forces to understanding them as integral ecological factors.

The Mediterranean region is characterized by a climate with a high risk of wildfire, which will intensify in the face of a climate change scenario. However, the population does not have the knowledge or the tools to prevent or react to these episodes and, the current model needs revaluation.

The Mefitu workshop advocates for experiential learning, emphasizing that complete risk avoidance is impractical. It highlights the inevitability of fires, especially in Mediterranean climates, where they may intensify due to climate change. The focus is on investing in prevention through sustainable forest management and fostering self-protection measures.

Beyond imparting knowledge, the project aims to cultivate values, skills, and a critical mindset among students to confront future wildfire challenges effectively. It stresses the importance of meaningful learning experiences rooted in students daily lives and involves the local community — including schools, families, land managers, and society — to enhance engagement and understanding (Figure 2).

/// Solution for a Resilient Future ///

The Mefitu workshop aims for experiential learning, engaging students directly with the topic of fire through various activities:

Audiovisual Presentation: The first part of the session takes place in the classroom through a dynamic presentation where the basic concepts of the Mediterranean forest, fire ecology, landscape management, and forest fires are explained. The presentation style varies between primary and secondary students. For younger children, the style is more interactive and visual, using simpler language and engaging visuals to maintain their attention. Activities are designed to be fun and educational, suitable for their cognitive levels. For older students, the content is more analytical, encouraging critical thinking and deeper understanding of fire ecology and forest management principles. The complexity of discussions and activities increases to match their cognitive development and learning capabilities. This segment also includes activities to assess students' prior knowledge related to the topic.

Origami Workshop:Students create trees, houses, and other figures belonging to a mosaic landscape from recycled materials, simulating both managed and unmanaged forest scenarios (Figure 4). This hands-on activity illustrates the difference in forest density and structure, emphasizing the importance of Forest Management in Fire Prevention. This activity is designed to be engaging for all age groups, with primary students focusing more on the creative aspect and secondary students delving into the implications of forest management decisions.

Story with Controlled Burning: Using the kamishibai format, characters such as firefighters, shepherds, and farmers explain the relationship between forest structure and fire behavior (Figure 3). Mockups of managed and unmanaged forests are burned to demonstrate the consequences of different management approaches. This storytelling method is adapted to be age-appropriate, ensuring that both primary and secondary students can grasp the key concepts through a narrative they can relate to.

Field Trip: Students visit a forest area, potentially one affected by wildfire, to immerse themselves in the environment and participate in artistic activities that encourage reflection on classroom learning. This experiential component enhances understanding and connects theoretical knowledge to real-world contexts, making the learning experience more impactful.

Teacher Training: Additionally, teachers receive half-day training sessions to prepare them for facilitating these activities effectively. The training includes an introduction to fire ecology, the Mediterranean forest ecosystem, and effective teaching strategies for engaging students. Teachers are trained on how to use the provided materials, conduct the hands-on activities, and lead discussions on forest management and fire prevention. This training is comprehensive and can also be applied to an adult civil society audience, making it versatile for broader community education initiatives. Teachers learn how to adapt the content to their specific local environment, ensuring relevance to the wildfires that occur in the area, their history, and the causes and consequences in the local ecosystem.



Figure 3: Story with controlled bruning.
Author: Pau Costa Foundation | © CC by Pau Costa Foundation



Figure 4: Kamishibai representation with firefighters, shepherds, and farmers explaining the relationship between forest structure and fire behavior.
Author: Pau Costa Foundation | © CC by Pau Costa Foundation

/// Always Moving Forward ///

The Mefitu Project is an educational initiative designed to raise awareness about the role of fire in the Mediterranean ecosystem and its effects. Implemented in numerous schools and diverse environments, it prioritizes areas with the greatest need for awareness, based on equal opportunity criteria and the relevance of forest fire issues.

Support materials for the project are developed with the following considerations:

- Resource Utilization: Using resources from various social, cultural, and geographical contexts, focusing on renewable materials.
- Educational and Enjoyable Materials: Providing resources that allow students to engage in combinations that are both enjoyable and educational, enhancing cognitive and emotional development.
- Developmental Adaptation: Adapting materials to the students' developmental levels, ensuring inclusivity and diversity.
- Model Building and Innovation: Ensuring students enjoy building models and are encouraged to innovate, fostering creativity and problem-solving skills.
- Creativity and Investigative Attitude: Promoting creativity and an investigative attitude driven by students' curiosity, aiming to instill a lifelong love for learning.

Field visits are a highly engaging component, offering firsthand experience of the natural environment and reinforcing classroom knowledge. To ensure a quality educational experience, sessions have a capped number of students, allowing personalized attention and active participation.

In 2023, Mefitu workshops were held in eight schools in Tarragona, funded by various entities including Diputació de Tarragona. The project continues to evolve, combining theoretical knowledge with hands-on activities to deeply engage and motivate students.

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Acknowledgment / Contribution

Trainers from the Fundación Pau Costa Foundation teach the activities, always trying to adapt the workshops to the needs of each school, and involving the support and expertise of Firefighters, forest protection groups, forestry workers, shepherds, and environmental agents can participate.

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The Pyropolis wildfire management serious game: development of an integrated fire management strategy in Cyprus

A participatory tool to foster collective intelligence and promote land planning for wildfire prevention.

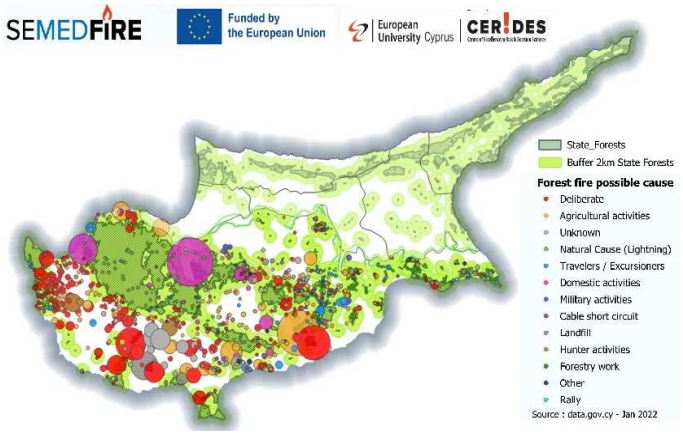


Figure 1. GIS analysis of wildfire, EUC-CERIDES, 2024.
Author: Matthieu Jost | © Educational use, non-commercial.

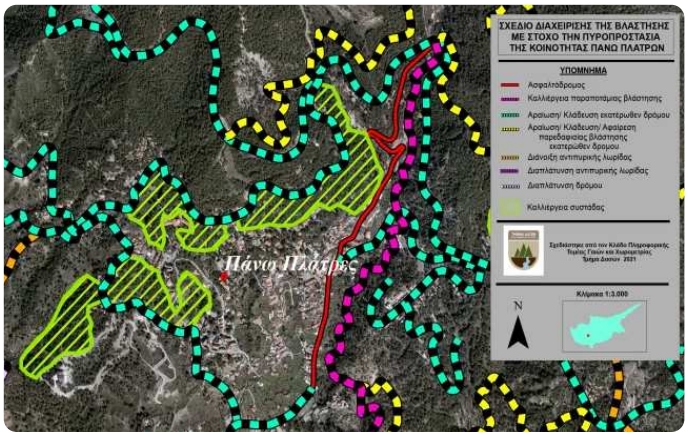


Figure 2. Vegetation management plan for fire protection of the community of Pano Platres.
Author: Department of Forests of the Republic of Cyprus, 2021
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/// Context ///

Cyprus is the third largest island in Mediterranean with an area of 9251 km2 of which 42% is covered with natural vegetation. The Department of Forests, which manages state forests, has the responsibility for fire prevention, suppression and restoration within state forests and within 2 km of its fringes.

Fire is by far the most destructive single agent, threatening the forests of Cyprus and no real progress can be made in forest development unless the forests are adequately protected. The long hot and dry summers, the frequent strong winds, the geomorphology of the landscape, and the flammability of the vegetation favour the frequent outbreaks and quick spread of fires. Furthermore, the urbanization, the abandonment of rural areas and the climate crisis raise the fire danger to very high levels.

The Forestry Department of the Republic of Cyprus is using GIS land use analysis (Figure 1) to develop vegetation management plans to reduce the risk and damage from wildfires. Figure 2 is an example indicating where thinning/pruning and removal of understory vegetation should be done: on road sides, fire lanes, etc. Getting these plans implemented outside of the Department of Forests' areas of responsibility is a real challenge.

A surprising interactive stakeholder's experience.

Three percent of Cyprus land burned by wildfire in 15 years.

In addition to this technical GIS analysis, as part of the EU-funded project SEMEDFIRE (GA no. 101079337, https://semedfire.eu/) coordinated by the Centre-of-Excellence in Risk and Decision Sciences of the European University Cyprus (EUC-CERIDES), specific work is ongoing: pertaining to emphasizing the need for wildfire land planning and integrated land management practices. This process raises political and legislative issues which need a progressive and comprehensive understanding of all parties.

In a workshop held in April 2024 to facilitate local stakeholders' involvement in elaborating a wildfire integrated fire management strategy for Cyprus, EUC-CERIDES has designed an interactive stakeholders experience ; a simulative Serious Game on wildfire management, entitled "Pyropolis", adapted from a previous game designed by Wageningen University and Research. This research abstract presents this serious game experiment and how it contributed to highlight the need for more resilience-focused land planning towards more effective wildfire prevention.

Pyropolis, a serious game on wildfire management to rise the understanding on the need of land planning.

/// Solution for a Resilient Future ///

In the previous context chapter, we highlighted that the GIS analysis is crucial for land planning but not sufficient. More than about technical issues, land planning is about political choices, and hence we should not wait for technical readiness to raise the issue at political level. Land planning is not an objective, but rather a path on which all stakeholders should be involved. Through this document we want to share the path and method we used, which permit to highlight the land planning issue as a key factor for integrated wildfire management in Cyprus.

The Department of Forests, in charge of fire prevention in the Public Forests, is not responsible for land planning, even in the 2 km buffer zone around the forests where it is mandated for wildfire suppression. A key point in land planning for wildfire management is to raise the understanding of all stakeholders that everyone has a role to play. Transversal approaches are needed, joining governmental authorities, research agencies, private sector and NGOs in collaborative events and actions.

In a workshop on April 2024, EUC-CERIDES facilitated an interactive stakeholder's experience by using "Pyropolis", a serious game on wildfire management which has been adapted from WUR's serious game "Pyrotown". The first objective of running this simulative game was to facilitate a better understanding of each other's roles, and hence to underline the need for collaboration. By asking participants to develop measures and strategies that help to reduce risk of wildfires and related risk communication strategies, it has been also the occasion to get inputs from participants to build-up an integrated fire management strategy.

The Pyropolis map (Figure 3) is representing the context of a small town neighboring a forest, thus suggesting the context of a Cypriot rural area while not targeting a specific real place, so as to facilitate appropriation. The different roles were adapted to the above Cypriot context, and role-descriptions for the following roles were developed to give to the players a better understanding of the goals of their role:

- Mayor/Political Leader of the Community/Town (with potential support by another role of "Head of Land Planning Office")
- Chief of the Fire Service
- Director of the Department of Forests
- Civil Defense and/or Police
- Representative of Farmers
- Representative of Environmental NGOs and/or Volunteer Organizations

Strategic land planning requires a holistic approach.



Figure 3. Map of Pyropolis, wildfire management serious game.
Author: Pantelis Valtadoros | © Educational use, non-commercial.

More than about technical issues, land planning is about political choices, and hence we should not wait for technical readiness to raise the issue at political level.

While running the Pyropolis serious-game, a number of land planning issues were raised. Some with the objective of facilitating intervention in case of emergency, and others focusing more on the reduction of fuel in abandoned lands. The main goal of the actions proposed by participants was to develop resilient landscapes; including biomass management, prevention and preparedness actions.

Access for fire services have been highlighted as a key issue, as well as the need for a strategic forest fire analysis to identify strategic management areas to ensure adequate opportunities for fire services to safely fight wildfires. This analysis indicated the key roads to be maintained and others that were suggested to be opened. It was suggested by participants that such roads (dirt paths) should be used by emergency services vehicles, but that they could be also accessed by tourists (hiking), so as to combine fire-prevention and preparedness with sustainable recreation in the rural area of the simulative game.

Participants proposed resilient landscape development of an agro-mosaic with more farming zones used as buffer-zones, such as vineyards or agroforestry plots in abandoned lands or controlled grazing in forested abandoned land. Participants were drawing on the map the adaptation of land use proposed to better protect the

Land planning is not an objective, but rather a path on which all stakeholders should be involved.



Participants drew on the map the adaptation of land uses proposed to better protect the communities.

Figure 4. Running Pyropolis wildfire management serious game, April 2024.
Author: SEMEDFIRE Consortium | © Educational use, non-commercial.

communities. The issue of biodiversity preservation was also raised through endangered species. The Pyropolis scenarios lay the ground for formulating preventive strategies, while also providing the opportunity for testing these strategies' effectiveness when fire occurs and the simulation escalates to emergency mode.

Another land planning issue raised was the need for evacuation and security plans, considering diverse groups of people, different communication needs and knowledge levels, including the designation of gathering/ rallying points, while as well the need for the use of an overall fire model.



Figure 5. Pyropolis serious game use injects to challenge players and their land planning strategy.
Author: Pantelis Valtadoros | © Educational use, non-commercial.

From a serious game to an integrated wildfire management strategy.

This specific workshop, including the interactive stakeholders' experience, was followed by another participative workshop on controlled grazing in strategic areas and another working session on strategic management areas. A complete report has been produced to structure inputs from participants and prepare the following-up collaborative workshops, which will occur in Fall 2024. The final goal of these workshops is to co-elaborate an integrated wildfire management strategy sustained by all Cypriot stakeholders.

Feed-backs from participants were very positive highlighting the need for more collaborative and transversal approaches. Complementary to the land

/// Always Moving Forward ///

All abovementioned participants' proposals for a better integrated wildfire management may seem obvious to a wildfire expert. However, the clue and interesting point here is that these adequate land planning actions for wildfire management have been proposed by teams comprising participants, of which most were in fact not wildfire experts. In addition, experts from the Fire Service and Department of Forests were actually not playing their own real-life roles but rather took up others (e.g. Farmer Representatives, Mayor, etc.). Nevertheless, we should highlight that before playing the Pyropolis serious game, all players had received introductory inputs from wildfire experts, as shown on the graphic recording on Figure 7.



Figure 6. Playing Pyropolis serious game, April 2024, Cyprus.
Author: SEMEDFIRE Consortium | © Educational use, non-commercial.



planning issue, participants also proposed to develop adequate governance & legislative framework to foster long-term planning and investments. Land planning need development and enforcement of laws and regulations concerning the use of fire, including clear rules for burning permit systems. The final report of the workshop stipulates that legislation that regulates forestry and biodiversity management in Cyprus should consider to promote and regulate the use of prescribed burning, agricultural, traditional fires, and controlled grazing.

Prescribed burning, as well as controlled grazing, are sensitive topics in Cyprus but the workshop and serious game facilitated the introduction of these issues in an open discourse with a wide audience comprising a variety of academic, governmental, private stakeholders, including environmental organizations interested in the biodiversity impact. The next step would be to raise the understanding at a more political level, so as to get support for a legislative adaptation aiming to transform (prescribed) burning and grazing from “uncontrolled threats” to regulated useful tools.

The final goal of these workshops is to co-elaborate an integrated fire management strategy sustained by all Cypriot stakeholders.

Legislation that regulates forestry and biodiversity management in Cyprus should consider to promote and regulate the use of prescribed burning, agricultural, traditional fires and controlled grazing.

Figure 7. Graphic recording of the workshop on integrated fire management, April 2024.
Author: Pantelis Valtadoros | © Educational use, non-commercial.

Taking into account the positive feed-back on the Pyropolis serious game, EUC-CERIDES is looking to adapt this stakeholders’ experience to foster fire risk management in education strategies. Such development would need to complete the serious game with in-built solutions that could be proposed to novice participants (solution cards). As such, the Pyropolis serious game could help to increase wildfire risk awareness and capacity to adapt and act, while also contribute to foster collaboration skills and collective intelligence.

Last but not least, risk communication to targeted groups and development of a better understanding of the fire risk in Cyprus is also one topic highlighted by participants which is strongly linked to land planning. Adequate, precise and shared GIS data is needed to ensure proper land planning. The needed GIS information should be acquired and shared, especially to research agencies to facilitate development of a more resilient landscape, protecting better our infrastructures and communities.

Building on this successful experience, EUC-CERIDES is now planning the next interactive workshops, which will include land planning as a wildfire prevention strategy. The direction that we will take, following an advice from AGIF, the Agency for the Integrated Management of Rural Fires, is to work on two lines, the short term focusing on quick-fix and the long-term planning, key element of an integrated fire management strategy.

Working on two lines, the short term focusing on quick-fix and the long-term planning, key element of an integrated fire management strategy.

Further information

- South Eastern Mediterranean Excellence Development In FIre REsearch (SEMEDFIRE) website: https://semedfire.eu/ (Accessed 15 August 2024). Detailed information on scenario, roles and injects of the Pyropolis serious game available on request.
- Agência para a Gestão Integrada de Fogos Rurais (AGIF) website: https://www.agif.pt/en (Accessed 15 August 2024)

Acknowledgment / Contribution
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Methodology of Forest Fire Potential Polygons

An operational tool to identify and manage uncertainty, provide an overview of the fire and explain what the fire can do.

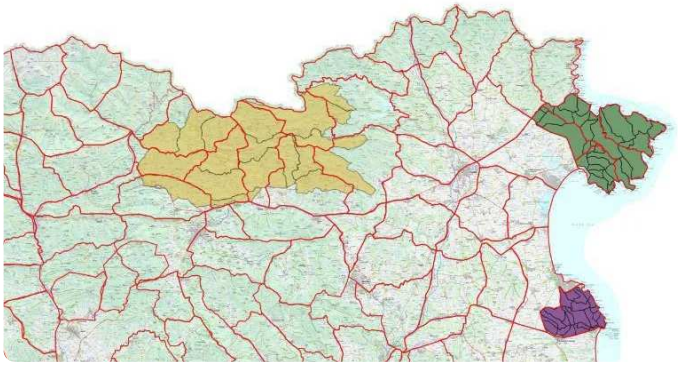


Figure 1. Map with the large-scale confinement polygons of Catalonia (in red) and the polygons of fire potential for three massifs.
Author: Catalan Fire and Rescue Service | © CC BY 4.0



Figure 2. General scheme of the methodology.
Author: Catalan Fire and Rescue Service
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/// Context ///

The strategic reasoning in fire analysis at Catalan Fire and Rescue Service (CFRS) was born in 1999 with the creation of the GRAF unit – a Functional Division of Fire Analysts/Operations on the Ground to anticipate opportunities – and it implied a change in the model of suppression of forest fires in Catalonia. The rationale for analysing forest fires carried out by the CFRS has evolved over the last 20 years. Currently, the aim of the analysis is to provide certainty in decision making by isolating the sources of uncertainty in these complex and changing forest fires scenarios.

In recent years, fire services in Mediterranean Europe have been overwhelmed by extreme wildfire behaviour. Consequently, fire management has moved to defensive strategies with a focus only on the known risks (the fear trap). In this region, wildfires can change rapidly, increasing the uncertainty and causing complex operational scenarios that impact society right from the initial hours. To address this challenge, proactive approaches are an alternative to defensive and reactive strategies.

As a scenario becomes more complex, the number of factors to monitor and analyse, and the interactions between them multiply: meteorology and specific climatology, status of fuels, statistics on activity/ ignitions, fire behaviour, fire types, critical scenarios, etc. There is too much or too little and we fail to really identify the changing information that is key to understand what is happening. We accumulate more and more information and decisions become more and more obscure and detached from reality.

Situational awareness' collapses when there is a very large amount of information that exceeds the control limits. In this situation, decision making will always come late, focusing on information and risks that are certain and losing sight of the uncertain ones. When there is enough certainty that there may be a change and what that may imply, it is often too late to change it (decision-lag). This can cause dangerous situations for responders, or in the best of cases it means not to be efficient in resolving the scenario. The aim is to achieve more resilient emergency systems and to avoid their collapse by analysing possible scenarios of resolution and the cost of opportunities.

Visualise what it needs to be avoided to identify the worst expected scenario based on strategic reasoning.

The polygons eliminate uncertainty and provide a clear and certain picture. Therefore, it is a way to trace decision making, communicate and increase credibility.

Situational awareness' collapses when there is a very voluminous amount of information exceeding the control stretches.

/// Solution for a Resilient Future ///

The polygons of fire potential are a tool for incorporating uncertainty into the decision-making process in a traceable and credible way. It is a way to plan what we want to do to achieve a resolution scenario. A scenario created by isolating the uncertainty and deconstructing the path the fire can take to achieve what is to be avoided. By isolating the uncertainty, it is possible to explain what is being done so that the consequences of the decisions can be seen in the decision making process, thus gaining credibility. This credibility gives strength to the emergency management team in making decisions about the common good and the most important values without falling prey to the pressures that dominate these complex scenarios. Therefore, in the use of the potential polygons as a tool for fire analysis, four premises must be taken into account:

- The deconstruction of the final scenario to be avoided in order to isolate the unknown factors of uncertainty.
- The traceability of decisions and their consequences.
- The constant iterative process of adapting the analysis to the complex scenario of emergencies.
- The fractal use of polygons in scenario analysis.
- The application of the potential polygons methodology facilitates decision-making at strategic and tactical levels:

1. Strategic decision making:

Containment polygons: these are macro-polygons that identify the consequences of decisions in order to establish large-scale priorities. They frame the resolution scenario, the territory where the incident is managed and focused on avoiding what we do not want to happen. Once the containment polygon is defined, the next step is to identify the multiple paths, the fire flows, that lead the fire to the place where it is to be prevented. Identifying the eight multiple paths is a process that is solved using the question of the analysis rationale What does the fire want to do? The answer to this question defines the maximum potential of the fire. It is the way to understand and have a global vision of the scenario. From this knowledge, the point where the fire is to be prevented is identified.

Possible scenarios of resolution: these are the grouping of polygons of fire potential according to the possibilities of achieving the objectives set out in the strategy of the

The application of the potential polygons methodology facilitates decision-making at strategic and tactical levels.



Figure 3. Potential burned areas (red) identified by numbers, the final perimeter of the fire (purple) and the icons of WUI areas of the Òdena's fire.
Author: Catalan Fire and Rescue Service | © CC BY 4.0

The analysis and its expression in polygons make it easier to provide criteria for decision making, directly linking the decisions with the corresponding consequences.

action plan. These polygons make it possible to identify the different possible scenario options according to the deployment and working capacity of the firefighting organization.

2. Tactical level:

- Polygons of fire potential: The contour used to delimit the polygons of fire potential that have been dimensioned above depict an area of the territory where there will be changes in the fire behaviour, which at the same time are work opportunities for fire suppression: i) changes in behaviour according to the propagation pattern of the fire, based on the critical points of the type of fire, bottom of the valley, crests, limits of the upwind, etc. ii) the opportunities for fire suppression work when the capacity to deploy resources is available. In this case, the line that marks the contour of the polygon indicates an area to work.
- Polygons for manoeuvre: these are sub-polygons of the polygons of fire potential used to plan the execution of manoeuvres within the established polygon of fire potential and according to the identified opportunity.

Examples of application of the methodology of Forest Fire Potential Polygons

We deconstruct because we do not know what will happen, but we can know what we do not want to happen and determine the steps that lead the fire to reach what needs to be avoided.

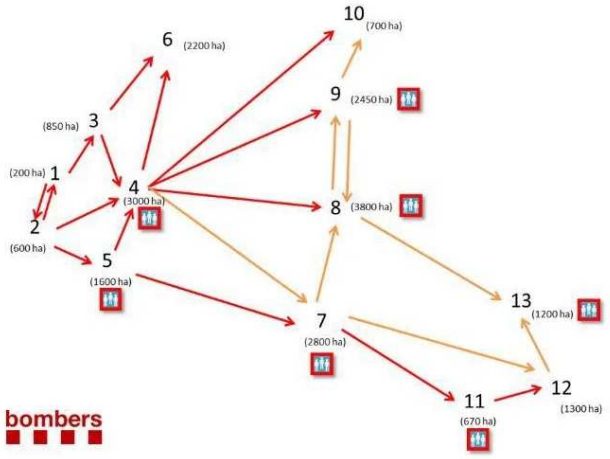


Figure 4. Diagram of the flows and probability of the fire flowing between polygons of the Òdena's fire.
Author: Catalan Fire and Rescue Service | © CC BY 4.0

Example. Containment polygons of the Tivissa's fire (2014)

The forest fire that occurred in Tivissa municipality (Catalonia, 2014) had the pattern of a wind-driven fire with subsidence. During the process of explaining the strategy and establishing the objectives according to the different scenarios during the day (with a sea-breeze from S-SE-E) and at night (with NW wind called Mestral locally), containment polygons were established in the large existing opportunities. It was also calculated the potential affected area associated with the cross of the fire through each of these large axes.

In order to make decisions about a scenario and communicate them, it is necessary to be able to explain what the consequences of these decisions are.

Example. Polygons of fire potential of the Òdena's fire (2015)

An example of the use of fire polygons in the analysis to facilitate the decision making of a forest fire is the case of the Òdena's fire (Catalonia, 2015) that affected the counties of Anoia and Bages. Figures 3 and 4 show the behaviour and information obtained from the polygons of fire potential and the fluxes of the fire used during the analysis of the fire.

/// Always Moving Forward ///

1. Adaptation of the methodology of polygons of fire potential to 6th generation wildfires

Wildfires classified as 6th Generation (or extreme wildfire events, EWE) are those that generate extreme behaviour, uncertain scenarios and can lead to collapse the emergency management system. This new type of fire has been identified and recognised at international level since 2017, although it has subsequently been possible to recognise examples of this extreme type of fire in previous historical fires.

The knowledge about these fires on a global scale is still in its infancy, but emergency management systems and organisations dealing with them are already working to improve and innovate their knowledge. These 6th generation wildfires are challenging in terms of the speed of the processes involved and the changes that occur, the multiplying factor of the processes, the behaviour of the fire with pyroconvection and the generation of Pyrocumulunimbus and also the great impact on the values of the landscape.

The adaptation of the polygons of fire potential to extreme scenarios makes it possible to use a proven existing tool for the traceability of actions and decisions in uncertain situations created by EWE. In the future, once more information is available on the behaviour of this type of fire, the methodology can be better adjusted to be adapted to take into account new knowledge.

Adaptation of the methodology of polygons of fire potential to 6th generation fires and to prevention planning.

2. Adaptation of the methodology of polygons of fire potential to prevention planning

The measure proposed for planning must be justified under a specific response scenario and, therefore this scenario should come from a methodological process similar to the process that is proposed to be applied during the response. For this reason, the methodology of polygons of fire can also be used in the planning process. With reference to the response capacity, usually the planner does not know which is the real capacity that the response organization could achieve the day of the incident, so this capacity is assumed from a hypothesis as one of the conditions that will be used for the design

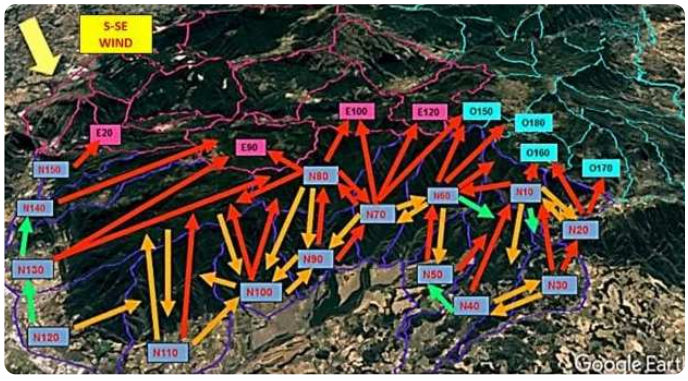


Figure 5. Potential polygons (purple) of the northern sector of massif of Prades (Catalonia) and the probability of passing between polygons (coloured arrows).
Author: Catalan Fire and Rescue Service | © CC BY 4.0

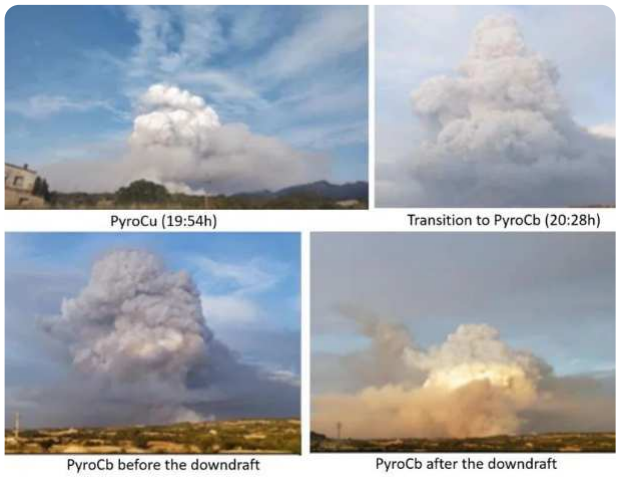


Figure 6. Evolution of the pyroconvection generated by the Santa Coloma de Queralt's fire of the 24th of July of 2021, and the transition from PyCu to PyCb.
Author: Catalan Fire and Rescue Service | ©CC BY 4.0

of the project that is on development. But the planners that faces this uncertainty should not take as a solution the non-incorporation of capacity in the methodological process.

If the planners do not include this element, unfortunately, there is a risk to fall into simplification because if the planners do not know the capacity of the organization of response, the polygons of fire potential would consider only one of the two elements that define the polygons of fire potential. If only one of the two elements are used,

As it has been observed during the fires, to prevent the fire from exceeding the containment area, efforts must be focused on preventing the fire from having the capacity to spread to extreme.

Strategic steps with focus on continuous collaboration between all stakeholders are needed to ensure the long-term success and sustainability of the restoration activities.

these polygons will describe only the homogeneous fire behaviour, which is only part of the job. In this case, it is important to be aware that scenarios becoming from a process of analysis that only contemplate the fire behaviour will not consider the capacity to deploy the responders during the day.

Example. Polygons of fire potential in planning for prevention of forest fires in the Prades massif

The Prades massif (Catalonia) has an orography consisting of many small and interconnected ravines. It has several fires of design that create a complex risk scenario, and it also has a well-studied history of past fires. The massif does not have a very marked structure of axes or lines from which the different scenarios of fire propagation can be clearly differentiated. Therefore, in this massif, planning was based on a matrix of potential polygons showing the small basins. This made it possible to add values and therefore accumulate the priorities, comparing different basins and establishing priorities. In this case, the fire flow diagram facilitates to compare scenarios and to decide which are the priorities and what impact they have on the future decisions of territorial and possible fire management.

Since 6th generation fires cause uncertain scenarios, the use of the methodology of polygons of fire potential can facilitate decision-making in these scenarios as well.

Further information

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Artificial intelligence to predict wildfire ignition and support response

An ignition probability map is used by decision makers to optimise the allocation of fire suppression resources across a vast territory of Mediterranean Turkey.

/// Context ///

In Turkey, about 230,000 km² of its 783,562 km² of land are covered by forests, mainly publicly owned. A significant portion of them burnt in the Mediterranean region in 2021 in the worst-ever wildfire season in the country's history. Around 80% of the fires are caused by humans due to urban expansion, infrastructures, and recreational activities. As early detection and initial attack are crucial,
it is important that the suppression resources are located as close as possible to the potential fire outbreaks. As a result, firefighting services are under great strain and require a high level of mobility. During the fire season, firefighters are stationed at fire stations near or within forest areas to extinguish fires as quickly as possible.



Forest firefighting workers extinguish and control a fire in Bodrum, Turkey, in August 2021.
Author: idiltoffolo | © Shutterstock

The Turkish Ministry of Agriculture and Forestry (TMAF) has been using a forest fire risk prediction tool based on meteorological parameters. However, meteorological data is not sufficient to assess fire risk if human activities are the main driver of ignitions, as they are unpredictable. Thus, there was an urgent and fundamental need for an ignition probability map that could take into account statistical as well as dynamic parameters, including human-made ignitions. Koç Digital created FireAId, an interactive fire risk map developed using artificial intelligence and machine learning that predicts
the probability of ignition in each area. It optimises the distribution of fire suppression resources across the territory.

/// Solution for a Resilient Future ///

The World Economic Forum's Center for the Fourth Industrial Revolution, Koç Digital, TMAF and Deloitte launched the FireAId initiative in January 2022. The goal of FireAId is to facilitate the use of artificial intelligence (AI), machine learning (ML) and other cutting-edge technological advances in predicting fire outbreaks and optimising the distribution of suppression resources in different territorial compartments for early detection and initial response. This effort is motivated by the need to increase the efficiency and affordability of forest fire fighting operations at country scale.

The output of this effort is FireAId, an interactive fire risk map developed using Al algorithms and ML, backed by a global community of experts. It provides crucial information for authorities to prepare and respond to fires, with simulation tools processing fire size, predicting progress, and evaluating firefighting tactics. FireAId has two phases:

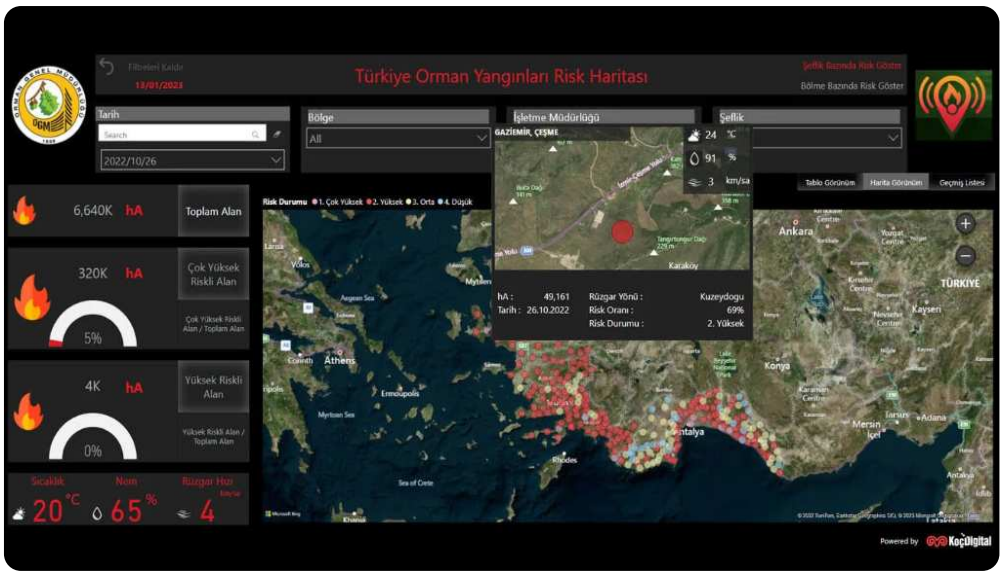
- An interactive map where predictive data (dynamic and static wildfire related datasets) are input to generate an ignition probability map.
- The ignition probability map is used to create an optimal post-ignition resource allocation model to help decision makers direct resources to predicted wildfires and identify potential threats.

FireAId pilot project has been developed for South Aegean and West Mediterranean areas of Turkey, which account for 44,000 km² of land. For the model, the area was divided into 66,394 territorial compartments. Historical data is used to train the models included the location, date, duration and size of any fire in the area since 2010, the means used to extinguish them in relation to different forest and land characteristics (vegetation and land features, land use types, and terrain) and the meteorological conditions before and during the fire (including the daily five-day weather forecast).

The output of the model is the probability of fire occurrence, with four classes of risk per territorial compartment: extremely high, high, medium and low. The model is run twice a day: once in the afternoon using current weather data, and once in the evening using the forecast for the next five days.

This pilot project in Turkey resulted in an 80% accuracy rate in predicting the ignition of forest fires. In 2023, FireAId is collecting users' feedback via a network of users: TMAF government structures. Afterwards, the model refinement phase will begin. New data on fire statistics, forest stand maps and meteorological data that can be integrated into FireAId system. By continuously improving the FireAId technology's learning techniques, researchers aim to improve its adaptability to the unpredictable nature of wildfires.

ForestAId required a highly specialised team of project managers, business advisors, business intelligence consultants, ML engineers, data engineers, data scientists and software engineers to ensure that every aspect of the project is covered. And for FireAId to be successfully implemented, there must be constant cooperation with fire experts. The entire budget of the project was covered by Koç Digital as a social responsibility project. General Directorate of Forestry (OGM) conducts benefit-cost analysis for all projects it carries out and implements. This analysis was also made for this project. Prioritising AI in wildfire prediction and prevention will improve the cost efficiency, effectiveness, and capacity of wildfire mitigation efforts at large scale.



FireAId interactive wildfire risk map.
Author: Turkish General Directorate of Forestry
© Turkish General Directorate of Forestry.

/// Always Moving Forward ///

Koç Digital developed FireAId for TMAF, which was launched at the World Economic Forum 2023 meeting. The initiative aims to help countries and organisations to model fire behaviour (including ignitions) under different conditions by integrating their fire, land and weather data into the FireAId system. The source codes and algorithms will be made publicly available, increasing the capabilities and impact of the FireAId initiative. The next phase of Koç Digital's FireAId initiative is to expand its solutions to entirely cover Turkey, and Koç Digital's risk maps, resource allocation models and fire statistics will help the TMAF with its annual resource allocation planning.

Forest fire fighting services are not an area that is the focus of high-technology companies, as is the case all over the world. High-energy forest fires that may occur in the future due to climate change will cause great damage to both forests and wildlife. The costs of extinguishing forest fires will increase dramatically. Identifying these negative impacts in advance could create new opportunities for high-technology companies in this area. To effectively manage the risk of forest fires and to avoid disasters, it is necessary to empower ministries, strengthen cooperation, incentivise contribution, prepare for long-term efforts. For Koç Digital to ensure the continuity of AI capabilities and to expand its capacities, the goal is to collect and enter as much data as possible into the FireAId system.

Further information

- World Economic Forum. 2023. The Next Frontier in Fighting Wildfires: FireAId Pilot and Scaling – Insight report January 2023. URL: https://www3.weforum.org/docs/WEF_The_Next_Frontier_Wildfire_Fighting_2023.pdf
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Acknowledgment / Contribution

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Authors: Eduard Mauri | **Partners:** EFI – European Forest Institute

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ResAlliance

Mapping compulsory brush clearing zones and strips

The French Forestry Code requires landowners to clear the vegetation surrounding their buildings and accesses. Online maps indicate who is affected and where the limits of their responsibility lie.



Figure 1. Compulsory brush clearing strips around building and access road.
Author: Mairie de Saint Christol lez Alès. | © Mairie de Saint Christol lez Alès, ©.



Figure 2. Determining who is responsible for brush clearing can become very complex when building strips overlap with each other and with those of public roads.
Author: Guide technique – Les obligations légales de débroussaillment.
© Délégation à la Protection de la Forêt Méditerranéenne & Office National des Forêts

/// Context ///

As a wildfire prevention measure, under the French Forestry Code, landowners in departments at high risk of wildfires, and within or less than 200 m away from forests, are required to clear the vegetation around their buildings in a buffer strip 50 m wide, and 10 m on either side of access roads (Figure 1). Brush clearing involves reducing all types of biomass (tall grass, branches, bushes and trees) to break the vertical and horizontal fuel continuity and reduce the intensity of a fire approaching a property. Methods include felling and pruning trees or shrubs, and removing cutting residues. In France, this regulation is known as **Compulsory Brush Clearing** (Obligations Légales de Débroussaillement, **OLD** in French). Brushing around buildings is compulsory by 1 July each year and must respect the technical criteria set by the town council or prefecture, published in the Local Town Planning Scheme.

Owners needing to clear beyond their own land must inform the neighbouring owners and request their permission to enter their property. The neighbours must grant the permit within a month, and if they do not, they will be responsible for the clearing. If the owners are unwilling or unable to clear the surrounding area by themselves, they can hire a forest works company. Town councils are responsible for monitoring the execution of the clearing. Controls are carried out without prior notification, and failure to properly implement OLD may result in fines.

> **Self-defence against wildfire with Compulsory Brush Clearing strips require precise mapping for their implementation.**

> **Landowners in départements at high risk of forest fires are required to clear the vegetation around their buildings, if located less than 200 m away from forests, in a buffer strip 50 m wide.**

These requirements can create complex situations for landowners to assess:

1. **whether they have an obligation to clear or not,**
2. if so, **what are the boundaries of clearing under their responsibility**, and
3. **what the final state of the vegetation should be** (as technical clearing criteria vary between departments based on local context).

Landowners can contact the town council or the prefecture to learn about the technical clearing criteria in force in their department. However, it can be challenging for them to determine if their property is affected and which area of the strip they are responsible for clearing, because when this regulation came into force, no map was published showing the location of the affected areas. Such cartography is also necessary for town councils to monitor the execution of the OLD (Figure 2).

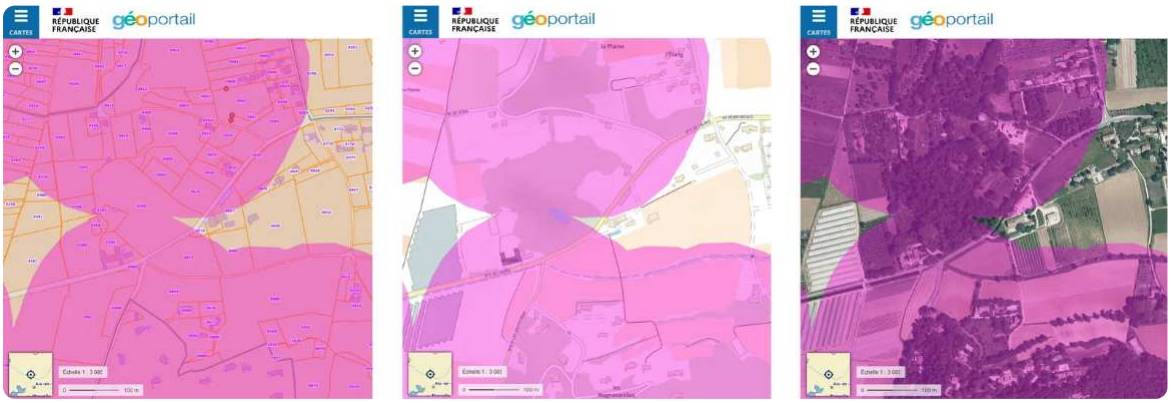


Figure 3. In Géoportail, OLD zones can be combined with other cartography (from left to right: cadastral plots, cartographic map, aerial photos).
Author: Géoportail
© Institut Géographique National.

/// Solution for a Resilient Future ///

Three complementary sources of information for landowners and town councils answer the three questions above:

1. Whether landowners have an obligation to clear or not

The When is brush clearance compulsory? webpage, in addition to explaining the Compulsory Brush Clearing regulation (OLD) in a language understandable to landowners, lists the departments that must comply with the OLD. However, a property is not affected by OLD if the buildings and access roads are more than 200 m away from forests. The Informative zoning of Compulsory Brush Clearing and *OÙDÉBROUSSAILLER.FR* map the areas affected by OLD.

The Informative zoning of Compulsory Brush Clearing map (hosted and published by the National Institute of Geographic and Forestry Information), in Géoportail, was the first to be developed. Géoportail is a comprehensive web mapping service provided by the French government that publishes maps and aerial photographs from over 90 sources for France. This map can be combined with any other cartographic layers in Géoportail (Figure 3). *OÙDÉBROUSSAILLER.FR* was created by the private company Optim.aize. It is a mapping web service exclusively focused on Compulsory Brush Clearing cartography. On both sites, users can enter an address and check whether it is in an area affected by OLD.

2. What are the boundaries of clearing under their responsibility

Only *OÙDÉBROUSSAILLER.FR* can answer this question. While *OÙDÉBROUSSAILLER.FR* shows the 50-m strip around each building affected by an OLD, Géoportail only maps the areas covered by an OLD (Figure 4).

OÙDÉBROUSSAILLER.FR maps strips affected by the OLD scheme based on the current prefectural decrees and orders. Magellium, a company specialized in GIS and cartography, conducted data analysis and generated

Making explicit an implicit complex cartography.

***OÙDÉBROUSSAILLER.FR* maps strips affected by the OLD scheme based on the current prefectural decrees and orders.**

cartography based on this information. The website eases the access and use of these cartographic representations. It also aims to aid local authorities in the implementation and monitorisation of the OLD.

The map displays, over a background of aerial photos, the vectorial layers for buildings, cadastral plots, and forests. Certain wooded areas less than 4 ha may not be visible on the map even though they are covered by OLD. This is due to difficulties in identifying certain forests, heaths, and thickets from photographic and/or digital data, and the reliability of these areas cannot be guaranteed. It is necessary to update these forested areas as regulations and forest cover evolve.

The map can be accessed using a laptop, tablet or smartphone. If the device has GPS, it can also locate the user's position on the map. Users can browse the map or search for a specific address using the search bar. Clicking on the searched building will tell the user if the property is affected by OLD and, if so, it will show the boundaries of the 50-m strip and the total surface area to be cleared (in m²) and the boundaries of the cadastral plots. The user can also view a wider 100-m strip, a some town councils require this clearing width.

If the town council has subscribed to a premium plan with *OÙDÉBROUSSAILLER.FR*, the area of the strip is displayed in two categories: non-forested areas (e.g. gardens) in yellow and forested areas in red, and their respective surface areas are given. In addition, the cadastral reference numbers of the plots are shown (Figure 5). Data is open access and available for download.

OÙDÉBROUSSAILLER.FR also provides information on OLD common to all French departments, including legal obligations, methods of clearing around buildings and roads, shared responsibilities when the 50-m strip overlaps with other tenants' land (private or public), and a calendar of possible actions.



Figure 4. Left: OLD as seen in Géoportail (pink areas indicate zones within an OLD). Right: OLD in *OÙDÉBROUSSAILLER.FR* (yellow and red areas show 50-m strip). Author: Left: Géoportail. Right: *OÙDÉBROUSSAILLER.FR*. © Institut Géographique National (left) and Optim.aize (right).

3. What the final state of the vegetation should be

The French Forestry Code dictates OLD technical brushing criteria (minimal distance between the house and trees, minimal distance between trees, minimal the height of pruning, etc.) for some French departments, while others have their own set of technical criteria. The When is brush clearance compulsory? webpage, in addition to explaining the Compulsory Brush Clearing (OLD, in French) in a language understandable to landowners and providing a list of the French departments which, being in a fire risk zone, must comply with the OLD, allows individuals to contact the municipalities concerned to find out the technical criteria for clearing, or to obtain them directly from the website of the municipality or the departmental prefecture.

/// Always Moving Forward ///

OÙDÉBROUSSAILLER.FR is adding new features to improve communication with the public on the risk of forest fires. Three new layers have been added in 2024. The drought warnings decreed, showing areas where drought conditions increase the severity of wildfires; the total area burnt since 2014, by municipality; and the average number of wildfires per year, by municipality.

It is appropriate for councils to subscribe to the premium plan. Currently, the premium plan shows the cadastral reference numbers of the plots under the selected strip: this facilitates the traceability of brushing responsibilities between landowners. However, the cadastral reference numbers can be obtained from the cadastral layer in Géoportail. The premium map also shows the surface area of a strip divided into non-forest and forest: this is crucial for budgeting the cost of brush clearing, because while the cost of clearing a garden, grassland or meadow may be minimal, the cost of clearing a forest or woodland is much higher. Neighbours on the same housing estate can share the cost of brush clearing if they decide not to carry out the work themselves. Currently, *OÙDÉBROUSSAILLER.FR* only maps the strips around buildings, but not along access roads. This is a possible feature to be added.

Optim.aize will offer two additional plans. The AI plan will provide the weekly fire weather index for forest areas, and the moisture level of the vegetation. The Analytics

Integration of different layers of information to have a more comprehensive wildfire risk assessment.

***OÙDÉBROUSSAILLER.FR* is adding new features to improve communication with the public on the risk of forest fires.**

plan will provide statistics and data visualisation for OLD at municipal, departmental, regional and national levels.

OÙDÉBROUSSAILLER.FR and the Informative zoning of Compulsory Brush Clearing layer in Géoportail are both used by forest managers in integrated fire management plans.



Figure 5. OLD strip (non-forest in yellow, forest in red) around a building, with cadastral reference numbers of the plots, as seen in *OÙDÉBROUSSAILLER.FR*.
Author: *OÙDÉBROUSSAILLER.FR.* | © Optim.aize

Further information

- Feux de forêt et de végétation : avant l'été, pensez à débroussailler! https://agriculture.gouv.fr/feux-de-foret-et-de-vegetation-avant-lete-pensez-debroussailler (Accessed 22 August 2024) (*In French*)
- Dans quel cas le débroussaillage est-il obligatoire ? https://www.service-public.fr/particuliers/vosdroits/F33298 (Accessed 28 August 2024) (*In French*)
- Zonage informatif des obligations légales de débroussaillement (in Géoportail). https://www.geoportail.gouv.fr/donnees/debroussaillement (Accessed 28 August 2024) (*In French*)
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Authors: Eduard Mauri | **Partners:** EFI – European Forest Institute

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ResAlliance

A network of agricultural land banks to connect agricultural entrepreneurs with landowners

The land bank is a mediation and intermediation service between people/entities looking for land to develop an agricultural project, and the owners of the land. By preserving the agricultural use of land (preventing land abandonment) forest expansion is halted and therefore the risk of large scale fires.



Typical mosaic landscape of the Conca d'Òdena land bank, in central Catalonia.
Author: Patxi Uriz | © Barcelona Provincial Council



The Baix Llobregat agricultural park land bank is dedicated to the cultivation of vegetables, and is just a few kilometres from Barcelona.
Author: Patxi Uriz | © Barcelona Provincial Council

/// Context ///

In Catalonia (Spain), 40% of farm owners are over 65 years old. The generational changeover within the family that continues to farm the land is decreasing, and from 2010 to 2021, Catalonia lost 17% of its agricultural holdings. Abandoned agricultural land often ends up being spontaneously covered by forest, which facilitates the spread of forest fires across the landscape, making firefighting more difficult and threatening human lives and properties.

On the other hand, there are more and more entrepreneurs in the agricultural sector, often attracted by life in the rural world, who are looking to grow food by developing their own business project, but do not have land on which to do so. The buying and selling of agricultural land is a very non-transparent market, if it exists at all, as owners often prefer to retain ownership of their land until death, even if it is not cultivated.

In order to prevent the loss of agricultural land, to give agricultural entrepreneurs access to land and to maintain a mosaic landscape, more resistant to large forest fires, land banks were created in Catalonia. In 2024, in Catalonia, there are twelve land banks working in a network, the Land Bank Network, present in 134 municipalities. The first land banks and the Land Bank Network were promoted and coordinated by Barcelona Provincial Council, through the BCN Smart Rural project, financed by the European Regional Development Fund.

/// Solution for a Resilient Future ///

The Land Bank Network arises as a proposal of the BCN Smart Rural project with the aim of establishing mechanisms for cooperation and continuous transfer in the implementation and consolidation of land bank initiatives in Catalonia. In addition, the Land Bank Network wants to become an incentive for the creation of new land banks, making available and sharing the knowledge and experience acquired. It offers a virtual platform to access information from all the land banks in the network, as well as their management entities.

The purpose of the online land bank is to contribute to the identification, incorporation and transfer to third parties of arable land, especially those that are abandoned or disused, with the aim of facilitating the recovery and access to the land, either to expand the dimension of exploitation and make it profitable, or to give access to New Farming (new entrepreneurs from the rural world).

All land banks have a register of landowners (and their plots) and applicants, which in most cases results in a digital platform where both owners and those seeking access to land can consult information about the land. Each land bank, covering several contiguous municipalities, has its own registration and therefore to access you need to contact your nearest land bank.

Once each managing institution receives the land search request or registration to add land, it will contact the applicant person or entity. In some cases, before the final registration, a personal interview with the land bank technician is necessary to learn first-hand the concerns of both the person requesting land and the characteristics and requirements of the person offering it.

1. Consultation of available plots

Once registered, the owner will be able to view his land on the platform, and the land applicant (agricultural entrepreneur) will be able to consult the available land.

2. Formalisation of an agreement

Once the lands and the people who are interested in them are known, the project proposal of the agricultural entrepreneurs will be evaluated and proposed to the ownership of the land. If both parties are interested, the establishment of a contract or formula that best suits the interests of both parties will be supported by the technicians of the land bank.

3. Deregistering

Owners can deregister their plots in the land bank at any time, through the platform or directly with the corresponding management entity.

Although the land banks are on-line, receiving advice from their technicians on the agricultural project proposals and the land transfer agreement are carried out in person at the land bank's office.

The use of the Land Bank Network platform and the services offered by the individual land banks are free of charge for landowners and agricultural entrepreneurs: the costs are borne by the local or regional public bodies that manage the network and the individual land banks within the network. The Barcelona Provincial Council, manager of the network and co-manager of four of the banks, contributes its previous expertise in agricultural development and in the creation of forest owners' associations in the province of Barcelona since the 1990s.



Distribution of the twelve land banks in Catalonia (Spain), in 2024.
Author: Daniel Farré | © Barcelona Provincial Council



A young agricultural entrepreneur visits the farm of a landowner who is eager to find a generational successor to his activity.
Author: Patxi Uriz | © Barcelona Provincial Council

/// Always Moving Forward ///

The Land Bank Network aims to be the platform for all projects and initiative of rural revitalisation and access to land emerging throughout Catalonia. In 2024, the Land Bank Network platform was in 134 of Catalonia's 947 municipalities, covering 591,104 hectares.

Some of the 12 current land banks in the network are stand-alone legal entities (mainly cooperatives), but most are embedded in local public bodies and supported by regional public entities.

In addition to their brokerage mission, the land banks also offer additional services, such as:

- Testbeds for future farmers before they create their own business.
- Subsidies for the promotion of professional agricultural activity, for farmers and owners.
- Advice, dynamization and training.

For landowners, the benefits of participating in a land bank range from improving and enhancing the value of their land, to renting it out for an economic return, to having well-managed land and minimising the risk of wildfire.

The development and establishment of the first land banks and the Land Bank Network platform were financed by the European Regional Development Fund (via the BCN Smart Rural project). Their current maintenance, and the creation of new land banks, is directly financed by local and regional governments, and public entities.

Further information

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Acknowledgment / Contribution

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Authors: Eduard Mauri | **Partners:** EFI – European Forest Institute

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ResAlliance

Ecosystem services certification supports the resilience of Mediterranean woodlands in Sardinia (Italy)

The experience of Agris Sardegna in supporting FSC® certification of sustainable forest management and eco-systemic services.

Forest Stewardship Council FSC Logo.
Author: FSC | © FSC



Cork stopper made from cork from certified cork forests.
Author: S. Maltoni | © Agris

/// Context ///

The use of wood instead of synthetic materials has gained importance worldwide, so ensuring that it is produced sustainably is an added value for derived products. Forest management certification ensures that forests adhere to principles that guarantee sustainability and eco-friendly management.

The most widespread international forest certification systems are FSC® (Forest Stewardship Council ®) and PEFC™ (Programme for the Endorsement of Forest Certification Schemes), which guarantee forest management in compliance with environmental, social and economic standards. There are various options to get certified: Single certification, for individual forest owners/managers; Group certification, for multiple forest owners/managers united in a single certificate; SLIMF (low intensity and commercial forests) for small, low-intensity forests, such as cork oak woodlands.

The Chain of Custody (CoC) certification, according to the FSC® and PEFC™ schemes, guarantees the traceability of materials from certified forests and is essential to be able to apply the FSC® and PEFC™ labels to products. It controls all the steps of the raw materials to ensure that the resources used are treated correctly by all the companies involved in the supply chain.
The certified products bear the FSC logo which guarantees that the product has been made with raw materials deriving from forests correctly and chain of custody of derived products.

forest certification guarantee that a forest is managed in compliance with rigorous environmental, social and economic standards.

Ecosystem service certification is possible, for a set of services that natural systems generate for humans, such as biodiversity conservation, carbon sequestration and accumulation, soil protection, protection of water resources or tourist-recreational-educational services.

The recent trends in ‘Closer-to-nature Forest management’ suggest the increasing role of such a schemes in guaranteeing final consumers and communities at large on the quality of management, and opens up new opportunities for forest managers connected to “conservation finance” or social accountability schemes for companies.

In recent years in the Region of Sardinia, considerable efforts were devoted to apply such standards in public and private forests, to support the increasing demand for sustainable rural development and forest management projects.

Forest Ecosystem Service certification case studies in Sardinia (Italy).

Ecosystem services are the set of services that natural systems generate for humans.

/// Solution for a Resilient Future ///

The Cusseddu Miali Parapinta was the first cork oak forest in the world to achieve the certification of sustainable forest management and all five ecosystem services according to FSC standard (SA-FM/COC - 001436; Code FSC® C018351). It is a public forest managed by the regional agency AGRIS. In the following years several other public and private farms achieved certification for ecosistem services.

These case studies certify the interest of public and private entities to achieve ecosistem services certification, though it implies several requirements. Fundamental to achieve certification is the drafting and implementation of a “Forest Management Plan” (PGF) valid for twenty years. The process to obtain FSC certification typically involves the following steps:

- Pre-assessment: The forest owner or manager evaluates their operations against FSC standards to identify areas needing improvement.
- Application: Submit an application to an accredited certification body, detailing forest management practices and commitment to FSC principles.
- On-site assessment: Certification body conducts a thorough audit of forest operations, including field inspections, interviews with stakeholders, and verification of compliance with FSC principles.
- Certification decision: Certification body evaluates audit findings and decides whether to grant FSC certification.
- Issuance of certificate: If compliance is confirmed, the certification body issues an FSC certificate, allowing the use of the FSC logo on products derived from the certified forest.
- Surveillance audits: Regular audits are conducted to ensure ongoing compliance with FSC standards and continuous improvement in forest management practices.
- Renewal: FSC certification is typically valid for a limited period, after which the forest owner or manager must undergo renewal audits to maintain certification status.

The objective of sustainable forest management is the application of forest management pursuing the production of cork raw material favouring natural renovation of the stands, in a closer to nature management attempt. The silvicultural interventions are often aimed at converting the forest from even-aged to uneven-aged and at preventing fires. Thinning of the adult tree layer and established renewal is carried out, as well as periodic clearing of the plots which affects only the aerial part of the shrub layer.

Cork from sustainable forest: case studies and how to do it?



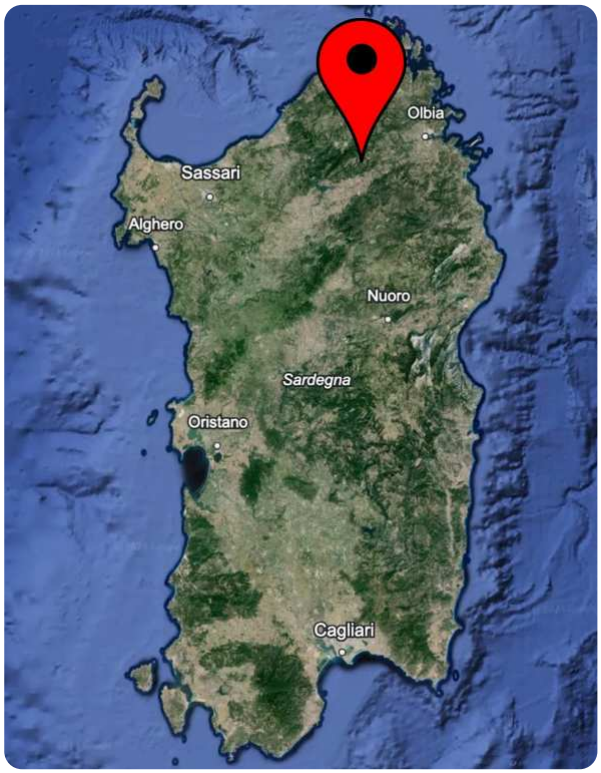
Cork extraction in the certified cork oak forest.
Author: FSC | © CC BY-NC

The objective of sustainable forest management is the application of forest management pursuing the production of cork raw material favouring natural renovation of the stands.

The data to be collected are those that demonstrate active management for the conservation or enhancement of ecosystem services:

- Examples for carbon stock include:
  - Reforestation implementation.
  - Plant inventory.
  - Creation of test plots.
- Demonstrating both the amount of carbon (stable or increasing) and your commitment to enhance the service.
- Examples for biodiversity include:
  - Floristic or faunal surveys.
  - Creation of refuge islands.
  - Maintenance of water points.
- Examples for water resources protection include:
  - Canal maintenance.
  - Hydraulic engineering interventions.
  - Ccreation of fire-fighting basins.

The foreseen duration is 5 years, and the audit entails a field audit and documentary audit. The FSC certification scheme is independent and third-party. In fact, inspections are carried out by over 30 certification bodies around the world. The certification bodies are themselves



The certified cork oak forest is located in north-eastern Sardinia.
Author: S. Maltoni | © Forestas

In terms of economic returns, the products of the cork forest are multiple, highlighting the possibility of multiple uses.

accredited by a third-party international accreditation body, the Assurance Services International (ASI). Obtaining the FSC forestry certification implies drafting and implementation of the Forest Management Plan designed on a twenty-year basis: a guiding tool for compliance with the criteria underlying the certification. The Plan contains all the actions aimed at guaranteeing the conservation and self-renewal of a complex ecosystem of fundamental importance for the Mediterranean Basin.

In terms of economic returns, the products of the cork forest are multiple, highlighting the possibility of multiple uses:

- Cork: sold on the plant or stacks with a public auctions.
- Firewood
- Acorns: used as a supplement for grazing and as controlled seed (seed forest).
- Mushrooms: sold in the local market, such as Black porcini mushrooms (*Boletus aereus*).

/// Always Moving Forward ///

Results: Five organisations and companies, both in the public and private sector, were certified for ecosystem services with the FSC standard between 2020 and 2023 in Sardinia (Italy) for a total of approximately 790 hectares:

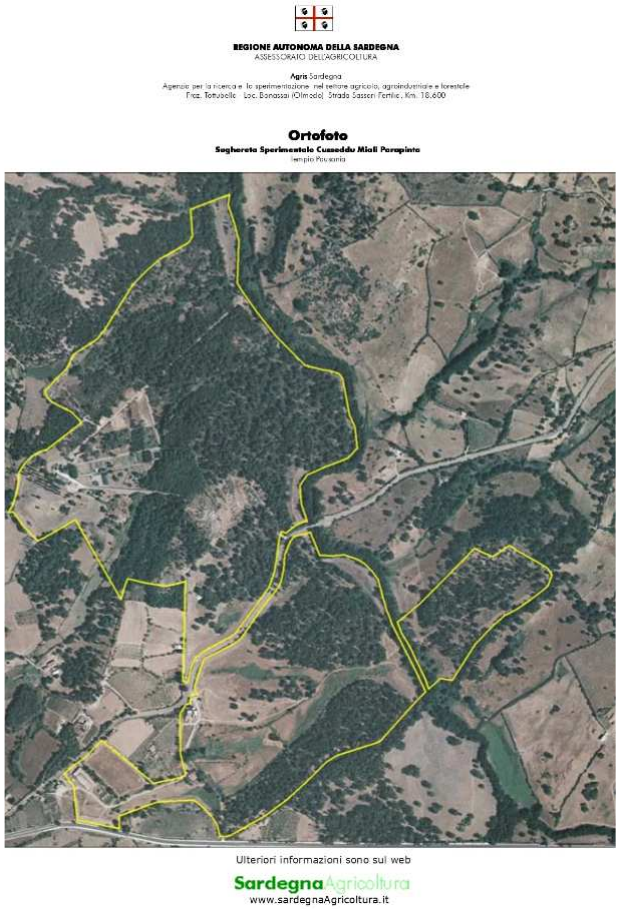
- A private agro silvo-pastoral farm got certified for for biodiversity and Carbon sequestration: the cork oak woodland of Masala Antonio – Villanova Monteleone (ICILA-FM/COC-004378; code FSC®- C173151).
- In the same year the private cork oak woodlands of Masu Gianna, in Luogosanto of around 28 hectares got certified for Carbon sequestration (ICILA-FM/COC-004356; code FSC®-165617).
- In 2022 the public forest of Monte Sant'Antonio de Macomer, managed by Agris for around 76 hectares was certified for biodiversity and Carbon sequestration (ICILA-FM-004413; code FSC® C174874) .
- In 2023 the Municipality of Alà dei Sardi certified around 464 hectares of cork oak woodlands and silvopastoral areas for all 5 ecosistem services (ICILA-FM/COC-004514; code FSC® C184531).

This represents a solid base for market-based instruments to increase investments in forest management and especially fire prevention measures, costly activities in low-revenue Mediterranean woodlands.

Forest certification is spreading through Sardinia.

Challenges: There is an increasing need for specialised technical consultancy for quantification of ecosystem services. Certification costs can be daunting: approximately 6,500-7,500 euros for 5 years, including ecosystem services. The price varies depending on the number of days needed for field audits, which in the case of cork oak are two as they are classified as SLIMF (low impact). The extreme fragmentation of forest properties is often a barrier for certification, for costs may be high with respect to the economic benefits.

Facilitation measures: At the national and international level, the interest of large companies in Italy (such as Conad, Gucci, Zegna, etc.) in investing in the sustainable management of forest areas is growing, as evidenced by the funding received from AGRIS and other ongoing negotiations. A factor that positively affected the results is the experience and professional support by the regional public agency AGRIS, and the competence of its staff on the agro-silvicultural certification. Another Agency, FoReSTAS, is seeking certification of large areas of regional forests, and may be the future case for large-scale adoption at the individual, group or regional level.



Aerial view of the cork oak woodland of Miali Parapinta.
Author: Agris | © Agris

Certification gives the opportunity to access emerging markets and partnering with investors.

One or more public entities, catalysing private first certification initiatives would be desirable to speed up the adoption of ecosistem sercvices certification schemes.

The tools developed by FSC make it possible to expand the concept of forest management, opening up innovative management directions, monitoring and verification of the impacts of management activities, and new opportunities for collaboration.

The Ecosystem Services Impacts of Sustainable Forest Management can be monitored through the guidance developed and made available to public and private owners of forest complexes by FSC "Guidance for Demonstrating Ecosystem Services Impacts" Guidance Document (GUI) V(1-1)28, which enables forest owners and managers to actively participate in safeguarding and enhancing ecosystem benefits for the community, while simultaneously taking advantage of the opportunity to access emerging markets and partnering with investors willing to promote their commitment to forest improvement and conservation.

Certification costs can be daunting: approximately 6,500-7,500 euros for 5 years, including ecosystem services.

Further information

- European Commission: Directorate-General for Environment 2023. Guidelines on closer-to-nature forest management, Publications Office of the European Union. https://data.europa.eu/doi/10.2779/731018
- FSC search website. All certified companies under the FSC standard mentioned in the factsheet may be found in the FSC database, selecting for the region of Sardinia (Italy). https://search.fsc.org (Accessed 24 September 2024)
- MEA – Millennium Ecosystem Assessment. https://www.millenniumassessment.org/en/index.html (Accessed 24 September 2024)

Acknowledgment / Contribution

Agris Sardegna – research agency in agriculture (https://www.sardegnaagricoltura.it/innovazionericerca/agris/).

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Partners: FoReSTAS – Agenzia forestale regionale per lo sviluppo del territorio e l'ambiente della Sardegna

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ResAlliance

ResAlliance

Type of solution: Finance, Governance, Management
Sector: Agroforestry, Forestry
Good practice(s): Ecosystems services

The FSC® Ecosystem Services Procedure

Ecosystem Services Impact Verification: Highlighting commitment to responsible forest management.



Forests play a fundamental role in the conservation and regulation of various ecosystem services that are essential for society.
Author: FSC Portugal | © FSC Portugal



Responsible forest management contributes to the conservation or improvement of ecosystem services provided by forests.
Author: FSC Portugal | © FSC Portugal

/// Context ///

Forests provide essential ecosystem services for society and are part of the solution to the climate and biodiversity crises we are facing. FSC certification allows forest managers to demonstrate their commitment to responsible forest management, but also to verify the impact of their management activities on the Ecosystem Services provided by forests. With the implementation of the Ecosystem Services Procedure, FSC provides forest managers with the necessary tools to value their forests and to be rewarded for the management they implement. By verifying the benefits produced by their forests, forest managers can communicate them and attract potential sponsors to support their management activities. By implementing the Procedure, the forest manager obtains high integrity, quantifiable data verified by a certification body, demonstrating and verifying the positive impact that the management practiced has on different ecosystem services. This data can be used by Organizations wishing to support areas with Impact Verification, thus creating an opportunity to value these areas and an additional economic support model for certified forest managers.

/// Solution for a Resilient Future ///

The FSC Ecosystem Services Procedure establishes a structure that allows FSC-certified forest managers to verify the impact of their forest management on ecosystem services, making it possible for external organizations to support them, demonstrating their commitment to responsible forest management. Currently, impacts can be verified for five ecosystem services: Biodiversity Conservation, Carbon Sequestration and Storage, Watershed Services, Soil Conservation and Recreational Services.

By verifying the impact on the conservation, restoration or improvement of ecosystem services, forest managers produce high quality data that can be used for Environment Social Governance (ESG) reporting. This entire verification process is audited by independent certification bodies accredited to work with the FSC system.The basis of this Procedure is the demonstration of impact on ecosystem services by the forest manager. The Procedure is implemented in areas with FSC forest management certification, and the necessary requirements must be met so that forest managers can measure and verify the positive impact that their management is having in terms of conserving, restoring or improving ecosystem services. The impact verification process requires compliance with several stages that can be summarised in 7 steps to be followed in order to demonstrate the benefits in terms of ecosystem services (see Figure 1).

The demonstration of impact required under the procedure means that a specific positive result must be measured and verified, and the management activities that contribute to it must be identified. Verifying this impact on ES makes it possible to make FSC claims on ecosystem services (ES claims). The ES claims can be used by the forest manager himself, in his internal communications or reports, or they can be used to establish partnerships with companies and organizations that want to support areas with impact verification and demonstrate their commitment to sustainability.

Companies are increasingly concerned about the environment and society, and FSC-labelled claims convey confidence that their contribution is having concrete effects on the ground and is having a positive impact on ecosystem services.

The FSC Ecosystem Services Procedure thus provides a solution so that managers can be duly rewarded for their positive impacts when carrying out responsible forest management. FSC ES claims can offer forest managers an additional incentive to become certified, or extra economic support for managers who are already FSC certified.

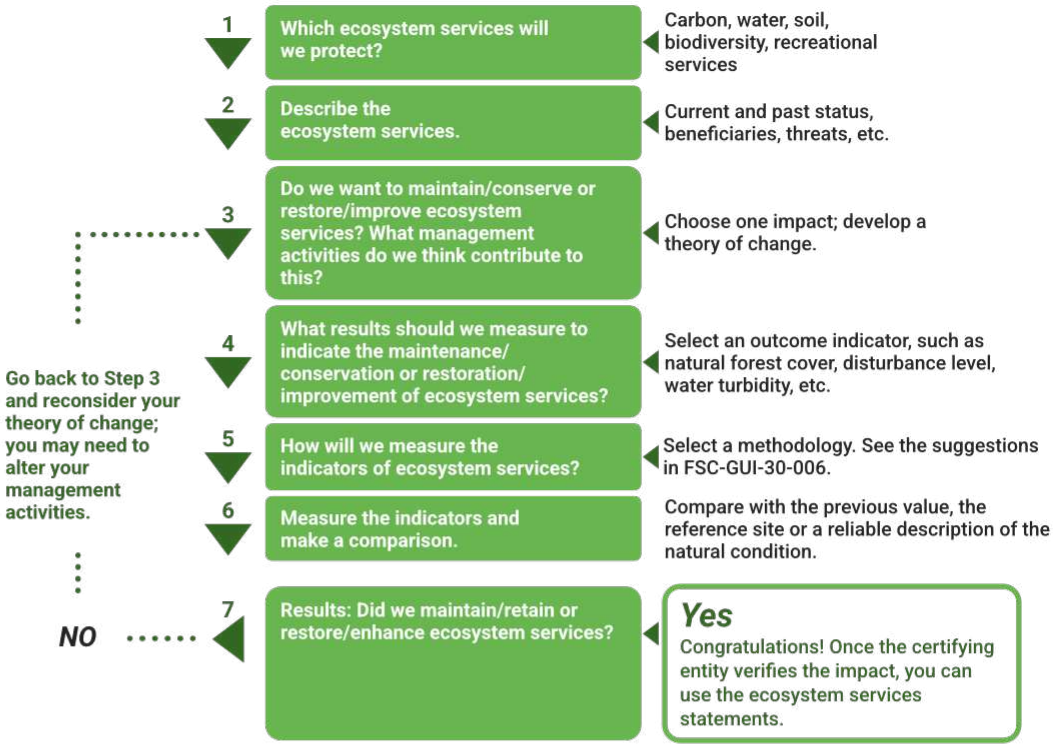


Figure 1 – The 7 steps to demonstrating impact on ecosystem services.
Author: FSC Portugal | © ©FSC Portugal

/// Always Moving Forward ///

The FSC Procedure is currently being revised with the aim of maintaining its relevance for both forest managers and potential sponsors. The new Environmental and Social Governance policies increasingly demand high integrity, reliable and verifiable information. The revision of the Procedure aims to respond to these issues, creating additional advantages for forest managers by enabling more effective contact with sponsoring companies.

Realising the importance of this contact, a platform was developed allowing companies or other interested parties to get in touch with these ES projects. Treender was developed with the aim of boosting relations by making it possible to consult all the FSC-certified ecosystem service projects implemented in Portugal. This platform allows a quick and easy check on which ecosystem services are being verified in each project and what are their impacts, as well as the location of the project.

This platform is a step forward in promoting the work done by forest managers in terms of ecosystem services in FSC-certified forest areas.



Valuing ecosystem services allows the unlock the full value of forests.
Author: FSC Portugal | © FSC Portugal

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Authors: FSC Portugal | **Partners:** ISA – Instituto Superior de Agronomia

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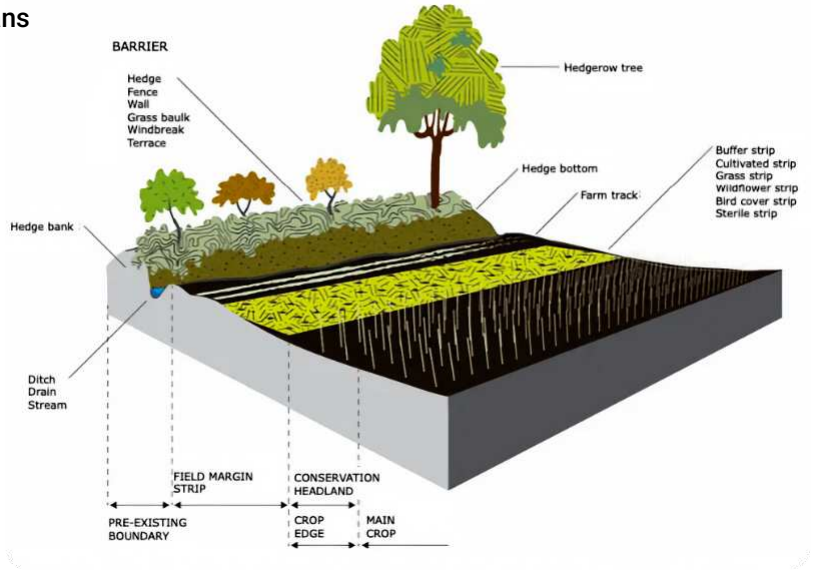
ResAlliance

The Resifarms toolkit: a tool for promoting education to enhance ecosystem services and build resilient landscapes

Developing the skills of farmers and agricultural technicians to conserve semi-natural habitats and promote the implementation of effective conservation actions.



Hay meadows and mosaic landscape in Angofa (Romania).
Author: XCN | © Educational use, non-commercial.



Drawing of a field with the associated semi-natural habitats.
Author: Marshall & Moonen, 2002 | © Educational use, non-commercial.

/// Context ///

The conservation of non-productive agricultural land, despite being included in the Common Agricultural Policy's (CAP) greening measures, is still being neglected. Despite this, farmers and agricultural technicians are increasingly recognizing the significance and advantages of conserving these areas for agriculture and its productivity. This includes substantial improvements in pollination, pest control, protection against wind or rain, and purification of water, among other benefits. However, they may lack the practical knowledge or tools to implement these conservation actions effectively.

In the frame of the RESIFARMS project, educational materials were created in several languages to help farmers and agricultural technicians manage the non-productive land of agricultural farms in order to enhance their capacities in conserving semi-natural habitats. The toolkit developed in the project pretend empowered stakeholders to build and enhance farmland resilience. The main objective was to promote the implementation of effective conservation actions that support agricultural production while also protecting and enhancing biodiversity and providing ecosystem services for agriculture. Additionally, the project carried out training and disclosure days and volunteer actions to implement some of these ideas in agricultural plots.

/// Solution for a Resilient Future ///

Farmland encompasses a significant portion of Europe's landscape, constituting 40% of total area. Farming practices wield considerable influence over biodiversity conservation, ecosystem services, climate change mitigation, and environmental quality. Consequently, farming plays a pivotal role in achieving the EU's 2030 biodiversity targets and related objectives.

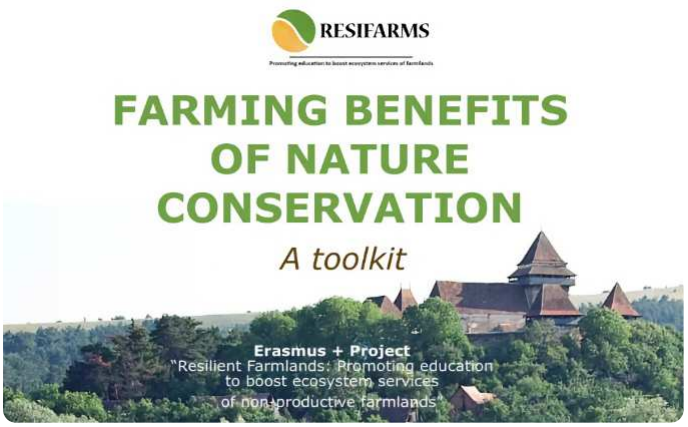
Efforts have been invested in optimizing fertilizer usage and curbing harmful pesticide application. Nevertheless, the conservation of non-productive agricultural lands within estates, despite their inclusion in the Common Agricultural Policy's greening measures as Ecological Focus Areas, remains overlooked. Farmers and agricultural technicians across the EU predominantly favor indirect, low-value conservation actions over more direct, high-value measures, largely due to a lack of comprehension regarding the benefits of conserving non-productive agricultural lands for farming productivity and broader societal and environmental health.

To address this challenge, the project's primary aim is to bolster the capacity of farmers and agricultural technicians in conserving non-productive agricultural lands, thus facilitating the adoption of more direct and effective conservation measures. Key actions include developing a free, open, tailored, high-quality toolkit to empower farmers and agricultural technicians, and fostering collaboration among stakeholders to preserve non-productive agricultural lands and enhance farmland resilience.

Targeting farmers, agricultural technicians,

conservationists, organizational staff, volunteers, and local/regional authorities, the project engages participants through various channels such as utilizing the toolkit, attending online trainings, volunteering, and participating in conferences. Its focus is on delivering tangible and intangible outcomes, including joint conservation projects, capacity building, and fostering collaboration to improve farmland conservation, enhance conservation measure application, strengthen sustainable farming practices, and promote land stewardship. The project methodology emphasizes practicality, tailored approaches, stakeholder cooperation, and tangible results. By shifting perceptions among the target audience regarding nature conservation, the project endeavors to achieve enduring benefits for farmland conservation and sustainable agriculture.

Semi-natural habitats within farmlands contribute significantly to biodiversity and farm resilience by providing resources for pollinators and pest controllers, offering protection against environmental hazards, and mitigating soil erosion. Collaborating with over 50 organizations, the project has developed a toolkit for conserving semi-natural habitats in agricultural lands, accompanied by four videos providing insights into habitat management and farmers' motivations for conservation efforts. The toolkit is organized in different tools, each rewarding a specific semi-natural habitat (e. g. field margins, hedgerows, or open spaces) or other relevant related topic like communication or supporting sources. The tools for each habitat summarize its main benefits for farming, management and creation practices and an initial conservation status evaluation method. These resources are freely accessible on the project website in seven languages, aiming to support farmers and stakeholders across Europe in conserving semi-natural habitats and promoting sustainable farming practices.



Cover page of the toolkit for the conservation of semi-natural habitats in agricultural lands focuses on the farming benefits of nature conservation.
Author: Unidentified | © Educational use, non-commercial.



Resifarms multiplier event in Sloup, Czech Republic.
Author: CSOP | © Educational use, non-commercial.

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The RESIFARMS project, which aimed to promote education to improve farmland ecosystems, ended in 2022. The toolkit will be available to download online, but it will not be developed further. From September 2019, Resifarms helped organisations to share knowledge, trained farmers and technicians, created training materials, improved habitats on farms, and raised awareness of the benefits of biodiversity. Five sessions were held to share the project's results with local people. Additionally, meetings were held in several countries to encourage collaboration and knowledge exchange between individuals associated with partner organisations. These meetings included discussion sessions and field visits to inspiring projects. Furthermore, various events were organised in different countries to disseminate the results of the E+ Resifarms project. The toolkit is also still being used in specific training sessions for farmers and technicians. However, the toolkit lacked detail in some tools. This was due to budget constraints. Although the project ended, there is still a need to promote the link between agriculture and nature. This is evident from the slogans used by European farmers in 2024.

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- Resifarms project. Promoting education to boost ecosystem services of farmlands. Erasmus+. The Toolkit. https://resifarms.eu/toolkit/ (Last access: 9 May 2024)

Acknowledgment / Contribution

We acknowledge Fundació EMYS for the materials provided and the enriching contributions.

Authors: Inmaculada Funes and Armand Casadó, IRTA | **Partners:** IRTA – Institute of Agrifood Research and Technology

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Type of Solution: Management, Technology Sector: Agriculture, Agroforestry
Good practice(s): Management alternatives,Community engagement

Resource Recovery and Reuse in Refugee Settlements in Ethiopia, Kenya and Uganda

Enhancing food and water security, access to energy and ecosystem and livelihood resilience in refugee-hosting landscapes through gender responsive and circular bio-economy innovations.

/// Context ///

In Sub-Saharan Africa, refugees are located in fragile arid areas. Despite many challenges, there are opportunities to shift from a 'land degradation' narrative to one based on 'land restoration and resilience', by enhancing the knowledge and skills of both refugee and host communities in a range of gender-responsive, regenerative and circular bioeconomy innovations, adapted to the local context. These innovations include, for example: to cultivate small home gardens irrigated with greywater; grow fruit and shade trees in their compounds; make briquettes from organic residues and soil; and build more efficient stoves from local clay – all of which reduce the impact on the local fragile landscapes caused by dense settlements. In the capacity-building process, newcomers and the host community are transformed from a social justice perspective, as agents of change, transforming ecological challenges and becoming active landscape restoration participants. The "Resource Recovery and Reuse in Refugee Settlements in Africa" project was carried out in 2019-2023 in six refugee camps and settlements and their surrounding host communities in Ethiopia, Kenya and Uganda. To date, it involved over 3,600 households and reached over 200,000 people indirectly in Kenya and Uganda. Due to conflict, no actions were implemented in Ethiopia. The evidence-based findings from this work are applicable to other fragile landscapes likely to experience massive arrivals of migrants and refugees in the future.



Home garden irrigated with household grey water and protected with tree branches in refugee settlement in Uganda | Author: Photo: Okoth E/ICRAF | © Photo: Okoth E/ICRAF

/// Solution for a Resilient Future ///

IWMI and ICRAF, in partnership with CIAT, Penn State University (PSU) and the Danish Refugee Council (DRC), UNHCR and UN Habitat, using a gender-inclusive approach, conducted a series of hands-on capacity-building activities in refugee camps and settlements and their surrounding host communities.

The innovative aspect of our approach involves integrating gender-responsive and context-specific adaptations of various technologies and innovations developed by various CGIAR research centers and universities while closely collaborating with key stakeholders in the humanitarian sector (e.g. authorities in charge of refugee camp settlements, UN agencies, NGOs as well as refugees and host communities). Regenerative and circular bioeconomy approaches foster synergies and help close carbon, soil nutrient and water loops. They thus enhance food and nutrition security, as well as access to cooking energy, and other ecosystem services provided by trees at the household level (Figure 1).

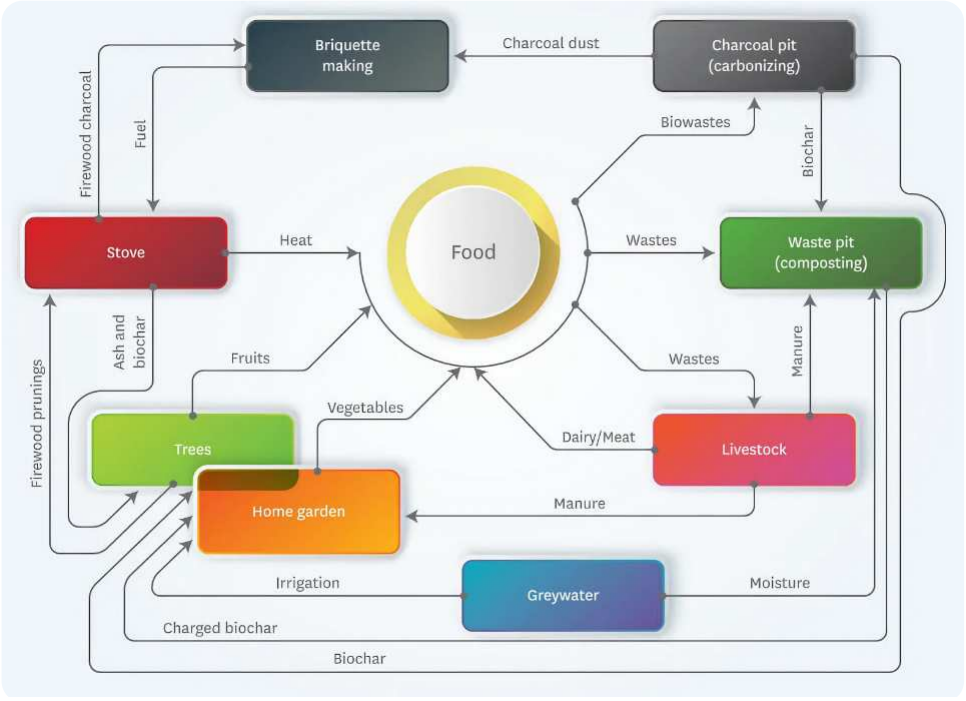


Figure 1. Synergies of carbon, nutrients and water flows between regenerative activities at the household level.
Author: Adam-Bradford et al. 2022 | © Educational use, non-commercial.

These capacity building activities were achieved through the Training of Trainers, applying a peer-to-peer capacity development model (Figure 2). Working with Training of Trainers or community facilitators, ensures the equitable participation of men, women and youth in project implementation as well as in enhancing capacity and the transfer of knowledge and skills at local level. As there is a need to reach multiple households for enhanced impact at the landscape level, the success of this project was measured by the number of households trained or indirectly reached, rather than by the area cultivated or the

kilograms of vegetables produced. Over 3,600 households (approximately over 18,000 people) implemented the home gardening, agroforestry and cooking energy innovations and over 200,000 people were reached indirectly.

Importantly, our approach is designed to be practical for women who already bear significant caregiving responsibilities. Gender integration and transformation was included from the initial conception of the project to implementation with reflective iterative learning that allowed ongoing self-correcting feedback as actions were modified to suit the needs of participants and the context for those individuals and communities as it became clearer (Figure 3). Training the project team on gender, having a gender researcher, budget and integration approach throughout the project life and management cycle is critical as it enhances common understanding and approaches and includes target end users' perception to meet their needs and aspirations.

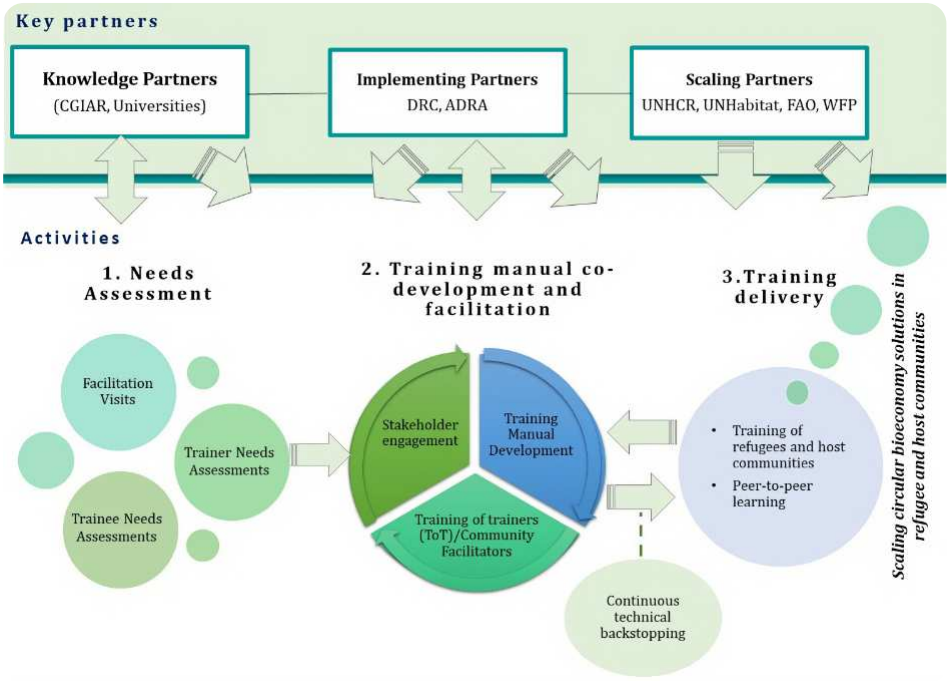


Figure 2. Capacity building and scaling framework.
Author: Gebrezgabher et al. 2024 | © Educational use, non-commercial.

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Several areas of improvement and further work have been identified. First, there is an urgent need for high-quality seeds. Community-based seed saving can help and there was some evidence of such activity. However, the next step would be to develop a local seed enhancement and replication effort for vegetables, fruits trees and other multipurpose trees to reduce the need to import seeds from outside the region. Second, the provision of continuous extension services from the community-based facilitators in both the refugee camps and host communities could bring greater impact. Due to budget limitation, only a small proportion of the households was reached and hence there is need for scaling to many more people, upscaling and adapting technologies and generating evidence on impacts for enhanced access to water and cooking energy and resilient landscapes and informed planning and programming. These resource recovery and reuse (RRR) innovations can be replicated and contextualised in the Mediterranean context as financial limitations affect humanitarian support and the need for refugees to be part of the solution for environmental and livelihoods resilience.

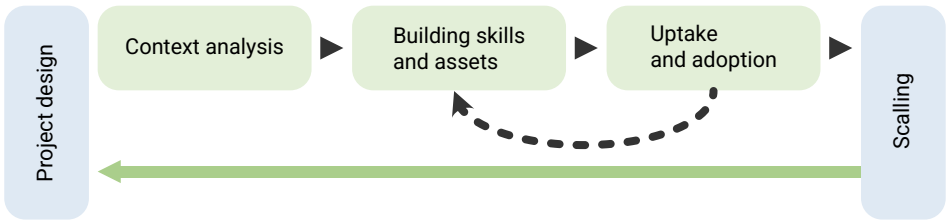


Figure 3 Gender integration in the co-designing and co-implementation of the CBE interventions.
Author: Gebrezgabher et al. 2024 | © Educational use, non-commercial.

Further information

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Acknowledgment / Contribution

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Authors: Mary Njenga, Ruth Mendum, Andrew Adam-Bradford and Solomie Gebrezgabher
Partners: CIFOR-ICRAF – Center for International Forestry Research and World Agroforestry

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ResAlliance

El Tribunal de les Aigües de València: Community-based water management

The Water Tribunal of the plain of Valencia (Valencian: Tribunal de les Aigües de València), serves as a judicial body for resolving disputes arising from the use of irrigation water among farmers within the Horta de València region.



"El tribunal (The Court)" in the 19th century.
Author: Josep Benlliure | © Educational use, non-commercial.



Plaça de la Virgen, in València. Where the Tribunal de les Aigües meets.
Author: Erin Johnson | © Educational use, non-commercial.

/// Context ///

The Valencia region has a Mediterranean climate, in which water is a precious and scarce resource. Around the capital city of Valencia, soils are also fertile, which has favoured rich agricultural fields. The Tribunal de les Aigües represents a particular form of water governance which has survived over the years. It is one of the most representative and valuable manifestations of the culture and traditional ways of life of the Valencians, and enjoys a wide degree of local, national and international recognition, which is why, in accordance with the provisions of Article 45 of Law 4/1998, of 11 June, on Valencian Cultural Heritage, it was declared an Intangible Cultural Heritage of Cultural Interest on 26 May 2006. In November 2009 it was declared Intangible Cultural Heritage of Humanity, which has turned into a tourist attraction, and raised concerns about the future of the institution.

The Tribunal de les Aigües is made up of the Trustees who preside over eight of the Irrigation Communities that irrigate the area of l'Horta de Valencia closest to the city of Valencia, an area traditionally known as the Vega de Valencia. The Trustees are democratically elected within each Irrigation Community by means of the vote of its members gathered in a General Meeting and must be farmers, owners and direct cultivators of their lands. They often enjoy a high moral and cultural consideration among the community members, which reinforces the authority of the Tribunal.

/// Solution for a Resilient Future ///

The Tribunal operates as a traditional court, comprising one representative, known as the síndic (syndic), from each of the nine Irrigation Communities (also known as WUAs), for in L'Horta de València region, covering an area of 8,804 hectares. Among them, one is elected president for a two-year term. Every Thursday, at 11h00, the Tribunal convenes publicly at the *Casa Vestidor* on Plaça de la Mare de Déu in the city of Valencia for its proceedings, which focus primarily on water distribution matters. In the event of a public holiday falling on a Thursday, the Water Court gathers on the preceding Wednesday. During these sessions, the bailiff, with the president's authorization, calls forth cases from each canal in succession, heralding their arrival with the customary exclamation *"denunciants de la séquia de*...!" ("claimants from the irrigation canal of...!"). Trials proceed swiftly and are conducted entirely in Valencian language, and they have been ongoing for over seven hundred years. *The Tribunal de les aigües* serves to members of the River Túria irrigation community to defend themselves against allegations of breaching customary water usage norms. However, the frequency of conflict among farmers is reportedly very low, and it has been the case for a very long time.

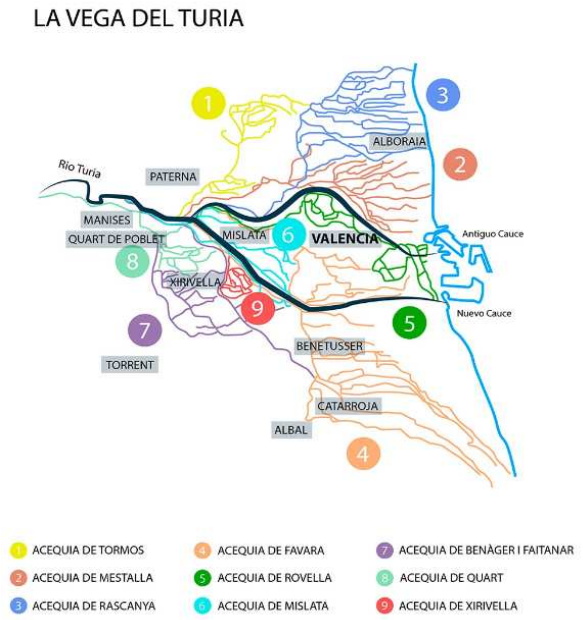
These WUAs are autonomous, each having its own written rules for using river water, known as ordenanzas, which can theoretically be changed at any time. Remarkably, these institutions have remained stable for centuries and are highly similar from one WUA to the next. Each WUA draws a fixed percentage of the total river flow, diverted into the eight main canals by permanent weirs called azuds, a term originating from the Arabic system of construction. The size of each flow was initially determined by the irrigated land area, which remained relatively stable until recently. However, in the last forty years, most WUAs have lost substantial land due to urban growth, which is making local farmers

rightly feel threatened by this ongoing encroachment, and of the consequences this may have on the water available for their crops.

Despite its murky origins, this institution has found its way onto the internet and into tour guides, serving as an intriguing example of local, community-based management of a natural resource—what economist Elinor Ostrom termed property regimes. Although the Tribunal's rulings are binding on community members, it deviates from conventional legal structures. In cases within its jurisdiction, a locally elected panel of syndics swiftly delivers judgments on-site during the weekly hearings. No records are kept, and there are no avenues for appeal. These syndics aren't legal experts but rather fellow water users who, like any other member of the community, can be accused, judged, and condemned. The court has become ingrained in the Valencian landscape, featuring in artwork and local literature, notably the works of the 19th-century Valencian master Blasco Ibáñez.



The Tribunal de les Aigües, along with former mayor of València Joan Ribó.
Author: Ajuntament de València | © Educational use, non-commercial.



Irrigation communities in the Horta de València.
Author: tribunaldelasaguas.org | © Educational use, non-commercial.

/// Always Moving Forward ///

The Tribunal de les Aigües has survived for several centuries, and it never discontinued its activity, nor even during the Spanish Civil war. The most recent disruption was probably the 14 months during which it did not meet openly by the door of the Apostles of the Cathedral. The future of the Water Court seems to be tightly linked to the future of the Horta itself, which has had several attempts of being protected, the last one with the Territorial Action Plan to Protect l'Horta de València, finalized in 2010 but finally not approved. The survival of the institution has been promoted by the important socio-cultural significance in the region. But most importantly, because it has served the needs of the members of the WUAs over time. Experts and activists are increasingly predicting that future conflicts will largely be held over water. Therefore the protection of a community-based institution like *the Tribunal de les Aigües* de València is essential. However, it remains to be seen how it can perdure over time, when both the water itself, but also traditional agricultural around the city of Valencia are at risk.

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Authors: Carmen Rodríguez | **Partners:** EFI – European Forest Institute

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ResAlliance

“How are we doing?” A tool to support decision-making in multi-stakeholder forums

A step-by-step reflection on the process, progress and priorities of your forum.

/// Context ///

Multi-stakeholder forums (MSFs) are spaces that engage a wide range of stakeholders in dialogue, decision making or implementation of activities around common landscape goals. They have gained much attention around the world because of their potential to improve collaboration by actors across sectors and governance levels to address complex challenges.
“How are we doing?” is a participatory reflective monitoring tool for MSFs. It creates a co-learning framework for MSFs to achieve their goal(s) equitably and effectively through a step-by-step process.
“How are we doing?” has three main features that set it apart from other tools. First, it was developed together with members of several subnational MSFs. Second, it was designed to be used by MSF participants themselves, not to be applied by external evaluators. And, third, its objective goes beyond a simple indicator assessment, rather inviting participants to discuss and reflect on their answers and jointly develop plans to improve the work of their MSF.



Alto Mayo Protected Forest multi-stakeholder forum, Rioja, Peru.
Author: Photo by Marlon del Aguila/CIFOR-ICRAF | © cifor-icraf.org

/// Solution for a Resilient Future ///

MSFs bring a wide range of stakeholders together to discuss common challenges and opportunities. MSFs have the potential to improve collaboration between different actors (e.g. government agencies, donors, NGOs, farmer organizations, Indigenous or local communities, academia), sectors (e.g. development, agriculture, environment) and governance levels (e.g. national ministries vs. local authorities) with the view to address wicked issues that cannot be solved by one actor alone. In bringing together different actors, MSFs may enable dialogue and decision making for the design, planning and implementation of collective strategies and actions linked with a specific topic or geographic area. They can also include actors that, throughout history, have not been able (or allowed) to participate in decision making on land-use issues that affect their rights, territories, lives and livelihoods.
Sometimes, power dynamics in MSFs can lead to situations where powerful actors can easily dominate the discussions and influence the decisions and resulting outcomes going their way. Hence, without equal and effective participation, the discussions, decisions and outcomes of MSFs may fall short of addressing inequalities and power asymmetries, and thus risking to legitimize the unequal practices in place. Recognizing these challenges, *“How are we doing?”* supports participatory reflective monitoring in MSFs. This handbook, resulting from a collaboration between members of MSFs and CIFOR-ICRAF researchers, was developed through a series of participatory workshops in Indonesia and Peru. The collaboration emerged from the need for a participatory tool to support equity and foster adaptive collaborative management in MSFs. Such a tool was designed to support MSF participants to monitor their forums; assess the progress made towards their objective(s); identify the challenges faced and the ones still ahead; reflect upon and improve their planning, processes and results.



ResAlliance LivingLab exploratory workshop. 17 November 2023. Vila Real, Portugal.
Author: SF-UTAD | © SF-UTAD

The handbook provides a step-by-step process on how to do that, organized around five stages and 15 steps (Figure 1). Implementing the full process may take three to four hours. A second version of the tool was co-designed with Peru's Protected Areas Service to support the multi-stakeholder management committees of the 75 protected areas in the country. It was made into an official government tool in 2021.

"How are we doing?" has three main features that set it apart from other tools. First, it was developed together with a wide range of actors, representing several subnational MSFs. Second, it was designed to be used by MSF participants themselves, not to be applied by external evaluators. Third, its objective goes beyond a simple assessment of indicators, rather inviting participants to discuss and reflect on their answers. The purpose of this reflection is to learn from the past, consider progress made and obstacles to further progress, and collectively plan how to achieve the MSF's goals in the future. For this exercise to be effective, organizers and participants need to be prepared and willing to make major re-alignments to their MSF when needed. Otherwise, the monitoring exercise validates the MSF's weaknesses rather than overcoming them, or fails to address exclusion.

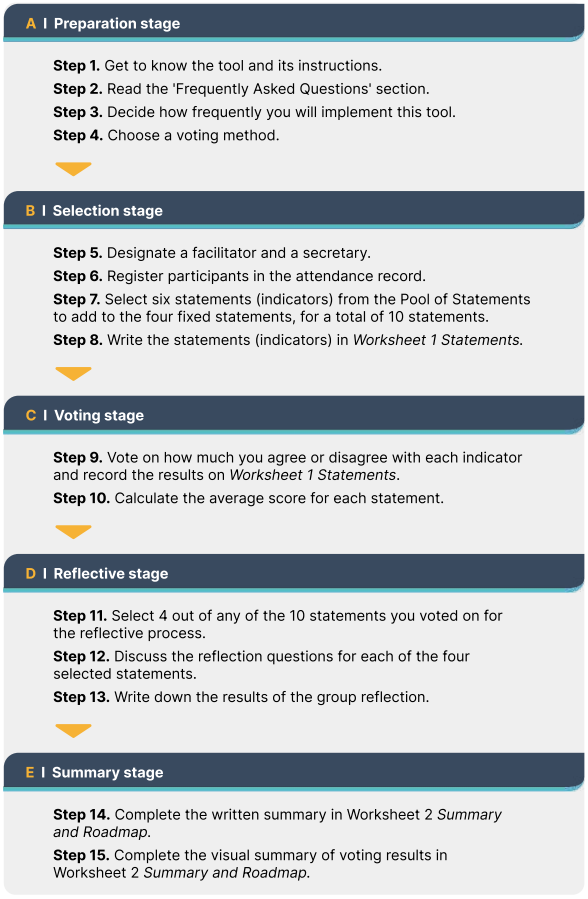


Figure 1. "How are we doing?" a step-by-step process
Author: CIFOR-ICRAF | © CIFOR-ICRAF

/// Always Moving Forward ///

"How are we doing?" continues to expand. The research team is currently working towards the second edition to the tool, after having developed versions with Peru's Protected Areas Service and the National Indigenous Andean and Amazonian Women's Organization. The team has developed a complementary set of seven "how to" guides to support the development of this tool and, more generally, the implementation of MSFs. These guides are all available online at: https://forestsnews.cifor.org/83160/power-politics-and-participation-naming-the-non-technical-in-multi-stakeholder-processes?fnl=.

The method will continue to be developed to support reflexive and adaptive learning and we would invite anyone interested in using the tool to get in touch with the team (j.sarmiento@cifor-icraf.org). In the future, this tool could be used to address the wicked and intricated challenges linked with landscape resilience. The ResAlliance LandLabs could be a privileged channel through which the tool could be disseminated, applied, tested, further improved and adapted to the Mediterranean context.

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Authors: Juan Pablo Sarmiento Barletti and Anne M. Larson | **Partners:** CIFOR-ICRAF – Center for International Forestry Research and World Agroforestry

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ResAlliance

A thematic social network to bring together Iberian agroforestry actors

The Iberian community of agroforestry and mixed farming ("Comunidad de Sistemas Agroforestales y Cultivos Mixtos") is a digital tool to promote knowledge exchange and cooperation between agroforestry actors, with a predominant role given to farmers.

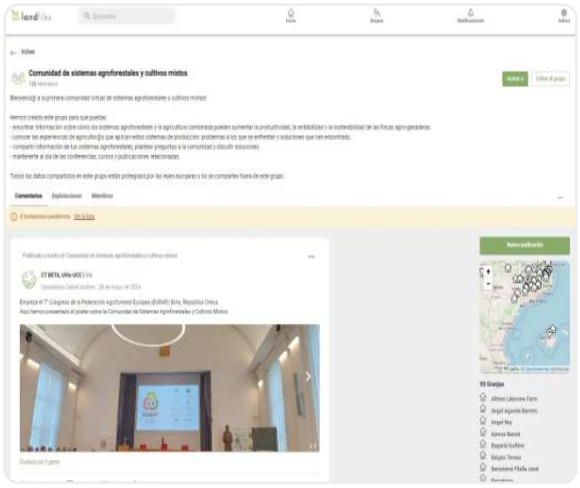


Figure 1. Front page of the "Comunidad".
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Figure 2. Map with the location of the Comunidad members by June 2024.
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/// Context ///

Agroforestry is highlighted in the European Green Deal and most subsequent strategies as a land use to be promoted because of its multiple social, economic and environmental benefits. These benefits include increasing overall land productivity, enhancing climate change adaptation and mitigation, protecting soil and water, and conserving biodiversity.

Despite growing interest, the uptake of modern agroforestry systems is limited by a lack of awareness of their potential among farmers, practitioners and public administrations, and a lack of capacity to design and manage them. These factors are interrelated and lead to (and are at the same time caused by) the low level of adoption of modern agroforestry systems.

The most effective strategy for promoting the adoption of new management practices is farmer-to-farmer exchange. Physical exchanges (i.e. field transfer days) are effective when and where there is a critical mass. However, when potentially interested adopters are scattered across the area, digital tools are a more feasible option, although the myriad of information can make it difficult to access targeted content. One available solution is thematic social media, a highly accessible and versatile tool for knowledge exchange among a given interest group. With this in mind, we created the "Comunidad de Sistemas Agroforestales y Cultivos Mixtos", a thematic social network focused on agroforestry and mixed farming systems.

/// Solution for a Resilient Future ///

The Comunidad de sistemas agroforestales y cultivos mixtos (Iberian Community of Agroforestry Systems and Mixed Farming) is a thematic social network that aims to promote the exchange of knowledge and associationism on agroforestry and mixed farming among farmers and with them with practitioners and researchers. The group focuses on Spain and Portugal. Farmers are the most relevant stakeholders addressed and are therefore given a priority position in the activities of the Comunidad. The community may be found here: https://landfiles.com/es/comunidad-de-sistemas-agroforestales-y-cultivos-mixtos

The Comunidad is hosted by Landfiles (https://landfiles.com), a multilingual French platform that aims to support and accelerate the development of new agroecological techniques. The platform is organised in tailor-made groups that bring together people interested in a particular agroecological practice, crop type or geographical context. Landfiles currently (June 2024) has more than 450 groups and over 12,000 users from 18 countries. The platform offers a free service to share images and comments. Paid subscriptions enable the creation of surveys and collaborative experiments, including data collection and analysis.

The Comunidad was jointly launched in spring 2023 as part of the PRIMA Transition (https://www.transition-med.org) and LIFE AgroForAdapt (https://agroforadapt.eu) projects, which had the common goal of supporting associationism in Mediterranean agroforestry. In late 2023, these projects joined forces with two other EU-funded agroforestry projects with Spanish and Portuguese partners (DigitAF –

https://digitaf.eu; and AGROMIX – https://agromixproject.eu) to increase the dissemination and adoption of this tool.

Besides the regular activity as a thematic social network, we organise quarterly live webinars with the whole community to allow live interaction between members. In these webinars, 2-3 agroforestry farmers present their farms: context, management, why they adopted agroforestry and the problems and opportunities they have encountered, etc. We also present news, projects, training opportunities, institutions and publications related to agroforestry. For example, in the first two webinars we introduced the Landfiles platform and the European Agroforestry Federation (EURAF). The recorded webinars are available to registered group members.

After one year, the Comunidad has reached 140+ members, of which 70% are farmers. Most of the members come from the Spanish regions involved in the two projects (Catalonia and Castilla y León), while there are representatives from 53% of the Spanish regions.

In May 2024, the Comunidad was appointed by EURAF (European Agroforestry Federation – https://euraf.net) as the entity representing Spain in the Federation, a milestone that should significantly increase the visibility and relevance of the Comunidad.

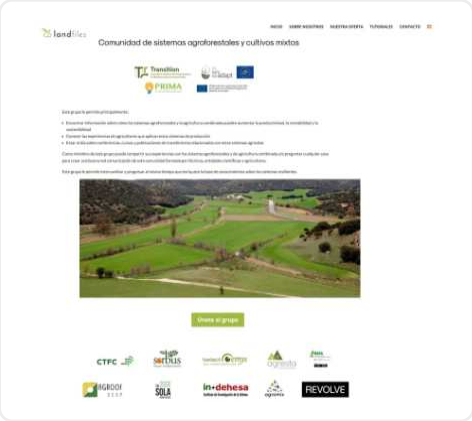


Figure 3. Layout of the Comunidad.
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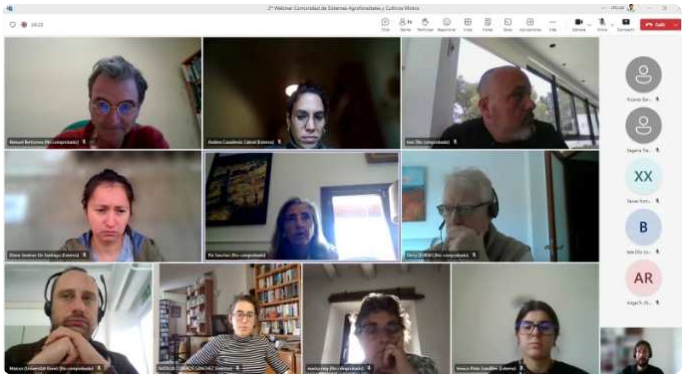


Figure 4. Second webinar of the Comunidad, June 2024.
Author: Not applicable | © Educational use, non-commercial.

/// Always Moving Forward ///

Up to now, the Comunidad has worked on the basis of the animation provided by the four ongoing projects, which help to disseminate the information, create content, support the registration of farmers, stimulate discussions and organise the webinars. However, these projects have an expiry date, so it is foreseen that their initiating role will gradually be handed over to the members, so that the Comunidad becomes increasingly autonomous, with the members taking the lead to ensure the continuation of these activities.

In this regard, an important step to be decided by the members is the possible transformation of this virtual platform into a legally established entity, probably in the form of an association or platform, so that it can act more effectively as a meeting place for agroforesters and to raise awareness of agroforestry, increase its adoption in new areas and promote it in policy development.

As the number of members continues to grow, consideration could also be given to promoting collaborative research activities between them, or to enabling sub-groups with a thematic or geographical approach to respond to specific technical issues and needs.

Further information

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Authors: Jaime Coello | **Partners:** CTFC – Forest Science and Technology Centre of Catalonia

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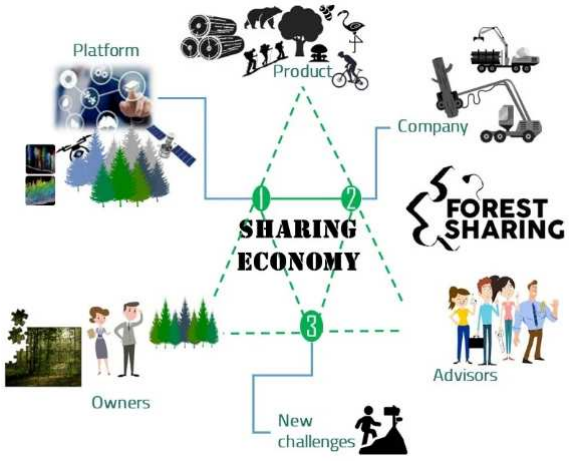
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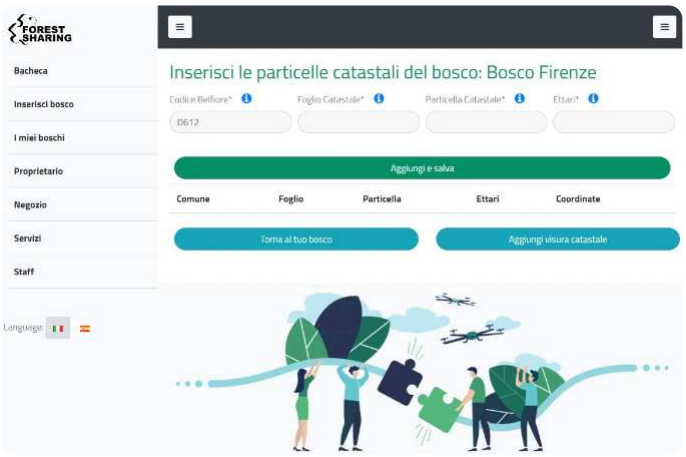
ResAlliance

Forest Sharing: the platform for taking care of forests

From Italy, a platform developed by Bluebiloba Startup innovativa to support small-scale forest owners and contrast abandonment and land fragmentation.



Alliance for Mediterranean Nature and Culture (AMNC).
Author: AMNC | © Educational use, non-commercial.



Farmer Field School on livestock management.
Author: Ibtissam Bouseta | © Educational use, non-commercial.

/// Context ///

The Forest Sharing platform was developed and launched in 2020 by the innnovative start-up and spin-off and the University of Florence Bluebiloba, to implement new strategies for forest management, enhancing multi-functionalities and re-boost communities. The platform aims to overcome one of the weaknesses of the Italian forestry sector: the fragmentation of forest ownership and the abandonment of rural areas. The tool was developed using a bottom-up approach, with the aim of being adopted by all forest owners. The ultimate objective is to provide an opportunity to reactivate the management of small forest holdings that are currently abandoned or unmanaged, through the use of a sustainable, multifunctional, collaborative and shared approach.

It promotes the adoption of appropriate silvicultural practices in line with the principles of sustainable forest management (SFM). SFM can maximize the benefits of forests in terms of ecosystem services, while reducing negative impacts. In this context, the Forest Sharing platform enhance the creation of a network that includes public administrations, forestry experts, forest industries and the whole forest-wood supply chain, together with forest owners and all relevant stakeholders, to enhance SFM practices and promote a landscape approach.

The Forest Sharing platform now counts 850 forest holders owning 23.000 hectares (ha) of forests, in all the Italian regions. Furthermore, a pilot test to aggregate public and private landowners for sharing a collaborative management approach, has been implemented in collaboration with the public administration in the region of Friuli-Venezia Giulia, in the north-east of Italy and the forest consortium “Boschi Carnici”.

/// Solution for a Resilient Future ///

The fragmentation of forest properties in Italy and in all Europe is one the most challenging obstacles to overcome when managing forests. In Italy, where more than 30% of land is covered by forests, 60% is privately owned, with an average of less than 3 ha per forest owner.

Forest Sharing is the solution tool to manage small and medium, unmanaged private and public forest properties, with an aggregative approach and following the best practices of sustainable forest management, overcoming forest fragmentation and abandonment, enhancing forest multi-functionality for climate change mitigation and a decarbonized future.

The platform serves as a digital area where forest properties with similar characteristics and management objectives can be merged, according to sharing economy principles, and applying the most innovative tools of scientific research and precision forestry. It is developed in web-GIS and it can be easily equipped with softwares, analyzing tools and decision support systems for making forest management sustainable and more efficient.

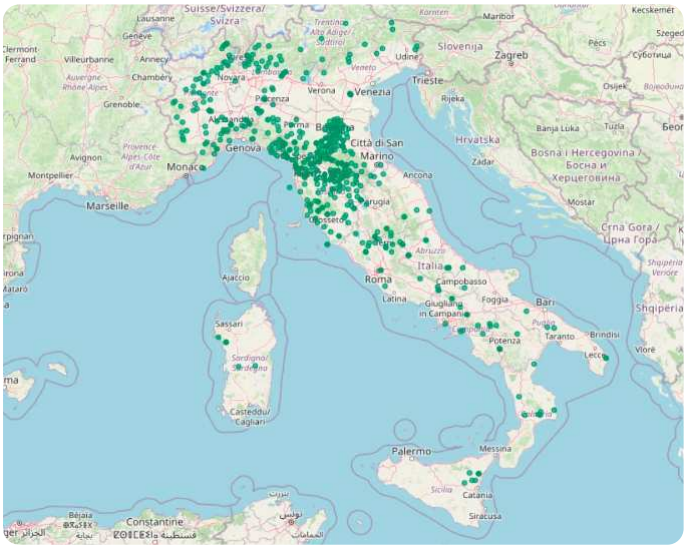
Forest owners can register free of charge on the platform, upload their forest parcels and select their management preferences among the options production, restoration, protection, fruition, recreation, conservation and the ecosystem functions they want to maximize. Owners can also choose between: a) continuing to manage their forest taking advantage of the platform’ services, such as matching with companies in the sector, precision forestry tools, participation in calls for fundings, or b) assigning management to Forest Sharing technicians who will carry it out in accordance with the selected preferences. Forest owners will then be listed on a bulletin board where supply and demand for forest services meet.

Forests in the same region or close to each registered in the platform are considered unified for forest management purposes, increasing surface and reducing management costs. Resources needed to implement projects and forest management plans come from integrated management, either from selling forest products or from public and private fundings.

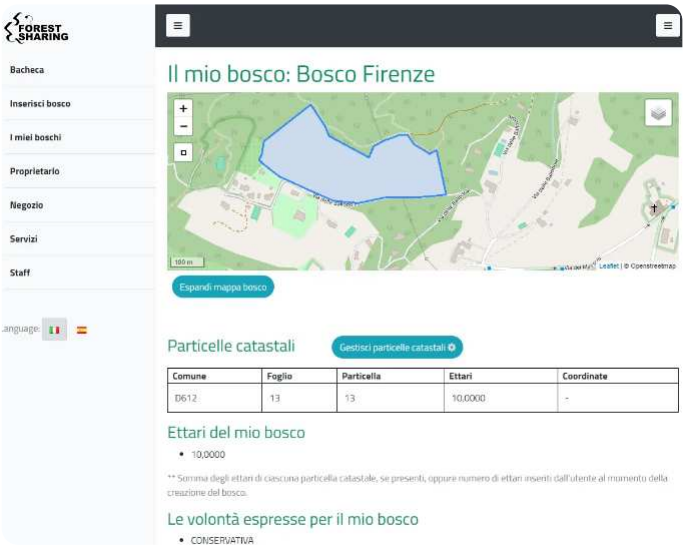
Nowadays in the Forest Sharing platform are registered 850 forest holders owning 23.000 hectares (ha) of forests, spread in all the Italian regions.

Data gathered so far indicate that forest owners that are attracted by the platform, decide to register for both reasons: owners that request technical support (less in number but more frequently), in many cases representing large and medium forest properties with production objectives and attitude, and owners that assign management to Forest Sharing (more in number but less frequently).

The Forest Sharing methodology has been implemented in public administrations in Friuli Venezia e Giulia, thanks to the "Consorzio Boschi Carnici", aiming to aggregate public and private landowners for a sharing and collaborative management. Public-private collaboration is therefore a winning choice, given the major problem of forest fragmentation in Italy, with the creation of a physical-digital desk for multi-actor forest management.



Location of cadaster parcels subscribed by users in Forest Sharing platform.
Author: Giannetti, et al., Land 2023, 12, 521. https://doi.org/10.3390/land12030521
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View of the platform for forest owner.
Author: Bluebiloba | © Educational use, non-commercial.

/// Always Moving Forward ///

Privately owned forests in Italy count about 6 millions ha. In this framework, the Forest Sharing platform, which has intercepted, so far, just 0.3% of those forests, needs to work intensively to strengthen its role and to have a significant impact on the Italian forest sector.

This, not only to overcome the depopulation of rural areas and the reestablishment of the wood supply chain, but to raise awareness about the importance of maintenance of forests and the provision of ecosystem services they provide among citizens. Forest sector difficulties are nowadays known just by forest practitioners, improvement should be made in communication to external communities.

The Forest Sharing methodology and platform has shown to have the capability to be scaled up outside Italy, in particular in other countries that have similar problems of fragmentation and abandonment. Forest Sharing is currently applied in H2020 and Horizon Europe projects such as SMURF.

Those initiatives will help to increase the platform recognition and contribute to the growth of our community, resulting in an increasing number of registered users and better managed forests.

Further information

- Bluebiloba Startup Innovativa SRL. University of Florence. www.forestsharing.it (Accessed 24 April 2024) (In Italian)
- Contact email: info@forestsharing.it

Authors: Ilaria Zorzi, Francesca Giannetti, Lorenzo Massai, Guido Milazzo, Bluebiloba Startup Innovativa SRL. Giulia Cecchinato, Etifor Srl Società Benefit
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TreesAdapt, a transformative partnership platform for adaptation

Adaptation with forests, trees and agroforestry for landscapes and people.



Traditional Quercus Ilex coppice system in a managed forest within the natural parc of Maremma, Tuscany, Italy | Author: Vincent Gitz | © Vincent Gitz



Trees provide food and feed in semi-arid areas and during the dry season. Silvopastoralism, Khejri, Churu District, Rajasthan, India.
Author: World Agroforestry Centre/V.P. Singh | © (CC BY-NC-SA 2.0)

/// Context ///

Forests, trees and agroforestry provide multiple ecosystem services for people and ecosystems. They are central to climate action, biodiversity protection, land restoration. They are key to the resilience of natural, rural and urban landscapes, to the livelihoods and food security of millions of people around the world. Inclusive, up-to-date and integrated knowledge generation and sharing is a precondition to maximize the multiple environmental, social and economic co-benefits of tree-based systems.

TreesAdapt is a transformative partnership platform aiming at supporting countries and actors in the development and implementation of climate change adaptation solutions for and through tree-based systems (forests, trees and agroforestry) in a range of contexts. Since its launch at the Global Landscape Forum (GLF) at Sharm El Sheik on 12 November 2022, TreesAdapt is developing, progressively including new partners and teaming-up with other initiatives on forests, trees, agroforestry and adaptation.

/// Solution for a Resilient Future ///

Forests, trees and tree-based systems provide critical contributions to climate change mitigation and biodiversity, and invaluable ecosystem services for people and ecosystems. They are key to the resilience of natural, rural and urban landscapes, and to the livelihoods and food security of millions of people around the world. With characteristics lifespan from decades to centuries, forests and trees are vulnerable to rapid climate change and critical for adaptation.

To maximize the multiple environmental, social and economic co-benefits of adaptation, the challenge is to plant the right tree, in the right place, for the right purpose. This supposes a knowledge-intensive and inclusive endeavour to avoid maladaptation, empower the most vulnerable people and ensure the relevance, credibility, legitimacy and effectiveness of actions undertaken. The wealth of existing knowledge, from various sources (scientific, technical, indigenous, traditional or local), also needs to be better integrated, organized, mobilized, oriented towards action and made more accessible to different stakeholders at different scales.

In this context, TreesAdapt, a transformative partnership platform, launched at the Global Landscape Forum (GLF) at Sharm El Sheik in November 2022, aims at supporting countries, farmers, businesses, national governments, international organizations and other actors in the development and implementation of climate change adaptation solutions for and through tree-based systems (forests, trees and agroforestry) in a range of contexts. Through intersectoral dialogues, TreesAdapt aims to facilitate the elaboration of a shared understanding on issues and the collective construction of solutions adapted to local conditions. Its findings will contribute to strengthen global narratives on climate action including joint mitigation and adaptation approaches and nature-based solutions, as well as to better link forests, agriculture and land-use in climate action.

TreesAdapt works all along the adaptation cycle (see Figure 1) to help countries and actors: identify climate change impacts on forests and trees; realize vulnerability assessments; identify and prioritise adaptation options; support implementation on the ground; monitor and assess effectiveness of adaptation efforts. It conducts a range of activities that can be grouped under four main clusters: knowledge generation; development of methods and tools; stakeholder mobilization and engagement; capacity

development, learning and communication. It focuses on the role of trees in the adaptation of forests, tree-based systems, farming, landscapes, watersheds and cities. In particular, it examines the determinants of people and communities' resilience; genetic resources; governance for an enabling environment; and knowledge (see Figure 2). Since the launch, TreesAdapt has organized a workshop at the margins of the UNFCCC SBSTA 2023 with about 60 participants from governments, financial institutions, technical and research agencies, Indigenous Peoples' groups, civil society and the private sector to discuss what forests and trees can provide for climate adaptation and how to finance further action.

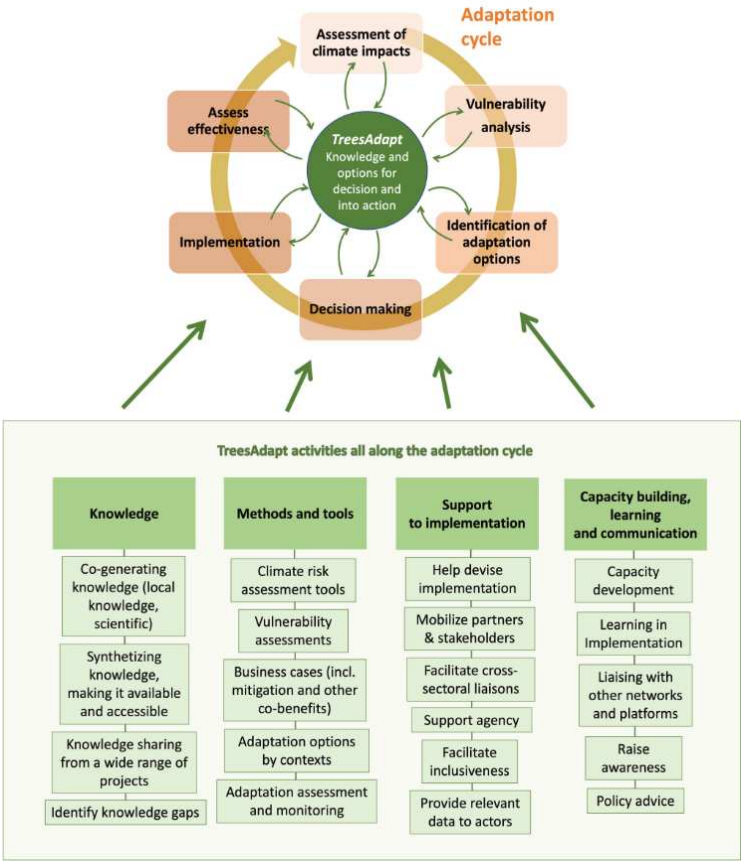


Figure 1. TreesAdapt supports actors all along the adaptation cycle
Author: CIFOR-ICRAF | © CIFOR-ICRAF

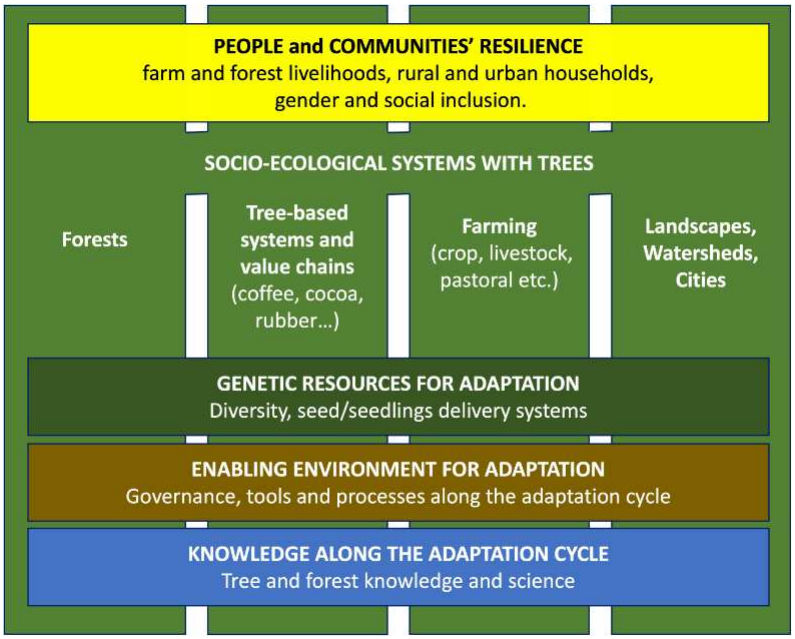


Figure 2. Key thematic areas of work of TreesAdapt along four tracks
Author: CIFOR-ICRAF | © CIFOR-ICRAF

/// Always Moving Forward ///

Next steps in the development of TreesAdapt are to finalize the formalization of the partnership platform; to develop communication and outreach and make the partnership better known to a wider range of organizations who would like to join; and to develop joint proposals between parties. The partnership platform will also be presented by CIFOR-ICRAF to the Forests, Trees and Agroforestry Partnership. The idea is to align existing initiatives, or team-up with other initiatives that could link with TreesAdapt, such as the Global Center on Adaptation. The workplan includes: a workshop between CIFOR-ICRAF and FAO, planned for the first semester of 2024; a discussion with INRAE on their initiative on forests, tree-based systems, and adaptation; as well as participation to a session at the 26th IUFRO world congress in Stockholm, Sweden, in June 2024, on "Building international initiatives to strengthen forest adaptation strategies in a changing climate". A further dimension is to establish linkages and synergies that forests and trees can provide between the agenda, policies and practice on adaptation and the agenda on mainstreaming biodiversity in forestry, agriculture, landscapes.

Further information

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Acknowledgment / Contribution

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“Forestry agreements” and “land associations”: two innovative tools for contrasting land abandonment and fragmentation

How national and regional legislation in Italy provide effective tools to ensure active forest management.



Mixed forestry in the Italian hills.
Author: Etifor | © Etifor



Italian hills covered by forest.
Author: Etifor | © Etifor

/// Context ///

In the rural and forestry context, land abandonment and property fragmentation are important and interconnected issues in many areas of Mediterranean Europe. These problems exacerbate the magnitude of climate change impacts and risks, such as forest fires and flood, and thus make it necessary to identify different functional tools to encourage active and responsible management in forest and rural areas. Therefore, in recent decades, at the Italian level, several initiatives have arisen, both at the national and regional levels, aimed at overcoming the abandonment of management activities by defining and promoting different models of aggregative solutions among smallholders. These aggregative forms can be based on both horizontal (among landowners, both private and public) and vertical (between owners and other actors of the value chain) models, as well as contractual tools to encourage active forest management and ensure positive impacts for local communities.

Although the arise of many of these initiatives has made the overall picture of these models very fragmented and not homogenous, two solutions seem to be the most interesting and effective in creating fruitful synergies between different actors, both public and private. These two solutions are: the “forestry agreement” and the “land association”. The first one is a type of innovative contract defined and promoted with specific national law in 2021 (Decree law n.77) the second one is a type of associative model, defined and promoted, through regional laws, by two regions of northern Italy (Lombardy and Piedmont).

Strong necessity to find a governance solution for reducing the land abandonment for addressing the impacts of climate change.

The forestry agreement represents a formal framework (a contract) in which forest owners, managers and users, can define respective roles and responsibilities in a clear and binding way, protecting the interests of each party. Whereas the land associations represent an aggregation of landowners with the explicit purpose of bringing together the lands of individual members (public and private) for one common and active planning and management.

The necessity to contrast land abandoment and property fragmentations.

At Italian level several initiatives have arisen promoting very different model of aggregative model among forest owners.

/// Solution for a Resilient Future ///

Since 1923, the Italian legislators, aware that the fragmentation of the territory would contribute to the abandonment of active managements with strong impacts, especially hydrogeological ones, promoted the adoption of different associative forms. In particular, Royal Decree 3267/1923 (art. 155) attributed the faculty (and financial resources) to “multiple municipalities and moral bodies” to form a consortium for “the hiring of a single director for the technical management of the forestry heritage”. After this very old national regulatory initiative, since the 1980s there has been a “regionalization” in the development of policy instruments to support landowner aggregation, as part of an administrative decentralization that also involved the forestry sector (Secco et al., 2017).

However, most policy instruments have not been effective in halting or reversing land abandonment driven primarily by urbanization, along with the continuing fragmentation of ownership due to the heritage system (Omizzolo, 2015). Therefore, more recently, regional and national legislation has sought to address the issue again through the use of innovative governance and policy instruments.

Regarding innovative governance tools promoted by regions, first the Piedmont region (in 2016) and then the Lombardy region (in 2019), followed the French example of “Association foncière pastorale” and the “Groupements pastoraux” have defined and promoted, through specific laws, the “Land Associations” in their territory.

The land associations are voluntary aggregation of landowners, based on a unitary management plan for the associated properties, in which the most appropriate technical and economic solutions should be identified, guaranteeing environmental and landscape conservation. Within the association, ownership rights are not altered, nor lands can be subject to usucapion; the land can be managed (according to the plan, commonly agreed) directly by the association, or can be entrusted to individual members or third parties (through lease contracts). A further important provision introduced by the Piedmont regional law is the possibility for land associations to be assigned abandoned, uncultivated, or silent lands (lands with unknown owners), by municipalities.

"Land associations" and "forestry agreements": two innovative tools for contrasting land abandoment.



Italian dense pine forest in coastal area.
Author: Etifor | © Etifor

In the last decades, at the Italian level, most policy instruments have not been effective in halting or reversing land abandonment.

To date, there are more than 60 land associations in Lombardy and Piedmont, most of which were established in the last 5 years. The high number of land associations created recently is evidence that there is a strong awareness among local actors about the importance of aggregating forest owners, through these new tools, to activate an active forest management, preventing forest abandonment.

Another important innovative tool recently provided for in Italian legislation is the “forestry agreements,” defined by a specific national law of 2021. According to the law, forestry agreements are explicitly defined as a “tool for the development of business networks in the forestry sector.” The participation of forest owners, whether private or public, or entities that hold real rights over forest properties is a mandatory requirement of the forest agreement. In fact, at least 50% of the signatories to the agreement must be forest owners. This allows owners to play an important role in the decision-making strategies of the supply chain, which the forest agreement aims to develop. One of the distinguishing and innovative features of these types of agreements is that compared to classic business network contracts, it is not necessary that all the contractors be entrepreneurs (Romano, 2022).

The land associations are voluntary aggregation of landowners, based on a unitary management plan for the associated properties.



Italian dense coastal pine forest
Author: Etifor | © Etifor

Forestry agreements are defined as a "tool for the development of business networks in the forestry sector". At least 50% of the members of the agreement should be forestowners.

As the law is very recent, at present, there are still very few forestry agreements signed in Italy, although those that have been signed have very innovative features. For example, the company Ledoga, which specializes in extracting tannins from chestnut, has signed an agreement with the forest owners' association located near its production site to facilitate the management of abandoned chestnut forest.

/// Always Moving Forward ///

Land associations and forest agreements are policy instruments recently defined by national and regional legislation to contrast land fragmentation in rural and forest areas. In both cases, the promotion and dissemination of these instruments in these early stages has been made possible mainly through public funds (Loreggian et al., 2023). In fact, with regard to land associations, both the Lombardy and Piedmont regions have allocated public funds, awarded through specific tenders, for the creation of the Land associations and the development of the management plan of these associations. As of 2018 to date, in Lombardy and in Piedmont almost the totality of land associations has been created thanks to these public funds. Most of these land associations are located in hilly and mountainous contexts and involve both agricultural and forest owners.

Numerous forest agreements, on the other hand, will also be financed in the coming years, through specific regional measures, in the context of the European agricultural fund for rural development (EAFRD) 2021-2027. For example, the Veneto region has already activated specific tenders, in the context of EAFRD, for the establishment of forest agreements in its territory.

While to date the economic sustainability of forest associations and forest agreements are primarily based on public funds, the main next challenge is to diversify revenues so that the activities of these innovative instruments can be conducted without public support.

Effective and efficient low-cost prevention involving the population, requiring, however, guidance and motivation.

The element of innovation was mostly in the way the technical work blended with the involvement of the local population in order to achieve better fire prevention efficiently.

About that, the ecosystem services market (like carbon stock) will have a great development in the coming years, and this can be an opportunity for the forestry sector. It is important that these types of innovative governance solutions, like land associations, will play an important role in this market, for ensuring a fair remuneration for forest owners who conduct active forest management, thereby improving forest ecosystem services.

At the moment, despite some proposed European regulations, such as the "EU carbon removal certification framework (CRFC), the regulatory framework of ecosystem services market is constantly evolving, and, currently, the only viable tools for attracting private funds for an enhancement of ecosystem services remain the forest certifications, like FSC and PEFC.

In fact, some of the Land associations recently established, such as Asfo Valli delle Sorgenti in Lombardy, to ensure maximum transparency for verifying and monitoring the impacts of forest management on ecosystem services, have decided to certify its forest area and its activities according to the FSC Ecosystem Services procedures (FSC-PRO-30-006).

Enhancement of ecosystem services, and subsequent payment, should be an important element in ensuring the economic sustainability of forestry agreements, as well. And, about that, the law by which they were defined clarifies that: "the purpose of the forest agreement is "the enhancement of public and private areas with agro-sylvo-

pastoral vocation, as well as for the conservation and provision of ecosystem services provided by forests". Therefore, forest agreements, as contractual instruments capable of involving individual, non-entrepreneurial, owners, aimed precisely at facilitating the remuneration of forestry activities conducted by individual owners, even small ones. The possibility to remunerate smallholders' forestry activities is a key element in reducing the phenomenon of forest abandonment and thus decreasing the magnitude of climate change impacts, such as forest fires and floods.

A small yearly investment in fire prevention, assigning/employing highly motivated specialized individuals to organize fire prevention activities can make a difference and can be cost-effective.

The fire prevention project in Kythira took advantage of the "window of opportunity", created by the disastrous fire of August 2017, which made the people on the island very concerned.



Forestry landscape in the mediterrean context.
Author: Etifor | © Etifor

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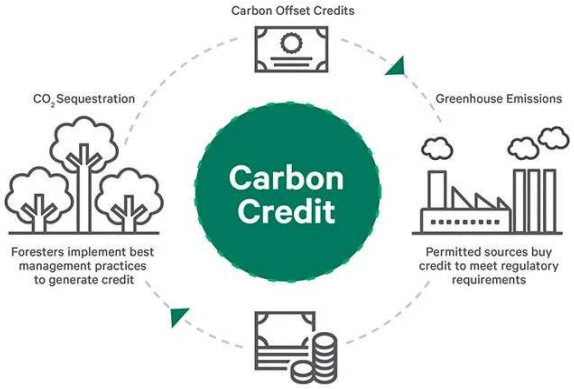
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Local Carbon Markets in Friuli Venezia Giulia and Veneto

Exploring the establishment of local carbon markets to address regional greenhouse gas emissions through the Carbonmark Initiative in Northern Italy, focusing on sustainable forestry and industry participation.

Carbomark project logo.
Author: Unidentified | © Educational use, non-commercial.



Representation of the operation of carbon credits based on forest protection.
Author: https://blueskyhq.io | © Educational use, non-commercial.

/// Context ///

The Carbomark initiative, part of the LIFE GoProFOR program, aims to establish a local voluntary carbon market. The novelty lies in the geographical proximity of the actors involved, which promotes a marketplace grounded in trust and increases the visibility and reliability of the carbon trading mechanism and with the main objective to promote solutions about the lack of evaluation/markets for ecosystem services.

Participants include buyers from small to medium polluting industries across various sectors, such as agriculture, chemicals, and metallurgy, and sellers mostly consisting of sustainable forest managers, wood producers, municipal authorities, and biochar producers.

Carbomark's primary goal is to mitigate greenhouse gases by increasing terrestrial carbon storage, but also serves several other vital objectives. It offers landholders an alternative revenue stream by compensating them for the ecosystem services their forests provide to the community. It encourages local governments to implement green policies and mitigation strategies and boosts the environmental accountability of medium-sized enterprises by aiding them in reducing or offsetting their CO2 emissions.

Although credit exchange occurs through direct contracts between buyers and sellers, where both parties assume related commitments, the benefits extend well beyond these interactions. By promoting a local market, the initiative ensures a reliable exchange network and drives sustainable community development.

/// Solution for a Resilient Future ///

Friuli Venezia Giulia and Veneto, two northern Italian regions, host many agro-industrial and metallurgical enterprises, as well as chemical-pharmaceutical industries, which contribute notably to greenhouse gas emissions. Under the Carbonmark initiative, two local voluntary carbon markets were set up in these regions.

These markets see participation from various entities that trade carbon credits through private contracts. The buyers include small to medium-sized businesses, multi-utility companies, and service providers not bound by the Kyoto Protocol's reduction obligations. Their participation is contingent on a commitment to carbon offsetting and insetting.

The sellers are forest owners, local governments, and individuals who engage in agroforestry practices aiding in carbon sequestration. Sellers must meet specific eligibility criteria and demonstrate their mitigation efforts to join the market. Market participation demands firm commitments from buyers and sellers regarding the duration of their involvement, adherence to agroforestry credit protocols, and restrictions on credit resale.

The Kyoto Observatories play a role in the market as facilitators by matching supply and demand, maintaining a carbon credits register, and ensuring compliance with commitments by all market participants.

The market framework also involves external auditors and trained technicians who oversee the market system and validate the credits.

The initiative aims for transparency by creating two “Carbon Market Observatories.” These observatories don’t directly participate in the market; instead, they monitor regional activities, define protocols for project implementation, manage purchase contracts, and maintain the structure and operation of the market, including establishing a credit registry and overseeing projects and transactions.

Regional administrations lead and coordinate market activities and partnerships, supported by the Universities of Udine and Padua. These universities handle the scientific and methodological aspects, developing agroforestry credit protocols and coordinating training for market operators and professionals.

Despite its innovative setup and flexibility in meeting emissions reduction targets, the Carbonmark market encounters challenges such as price volatility of CO2 credits, which affects long-term investments, and high transaction costs. Concerns also exist about the effectiveness of emissions reductions, as companies might need to reduce their source to offset emissions.

However, by the end of the project, the markets were operational, involving public forest owners, small to medium-sized businesses, and local governments, proving the feasibility of regional carbon markets.



Presently, ruled market systems operate worldwide and promote emission offsetting mechanisms producing global effects.
Author: Unidentified | © Educational use, non-commercial.



Carbomark peculiarity is a local scale implementation, which means real geographical proximity between sellers and buyers of carbon shares.
Author: www.travelglobe.it | © Educational use, non-commercial.

/// Always Moving Forward ///

Carbomark is a pilot initiative setting up a voluntary carbon market whose peculiarity is a local scale implementation, which means real geographical proximity between sellers and buyers of carbon shares.

Presently, ruled market systems operate worldwide and promote emission offsetting mechanisms producing global effects. However, they do not stimulate closeness between greenhouse gas (GHG) emitters and offsetting initiatives. For this reason, operating locally facilitates the achievement of environmental benefi ts in the same areas where GHG are emitted.

The success of the Carbomark Initiative has led to calls for this model to be replicated in other regions such as Piedmont and Rome, underscoring its potential for wider impact and expansion.

In addition, in order to give continuity to the Carbomark experience, the Veneto Region is actively collaborating with the UNI working group for the preparation of a new technical standard which lays univocal basis for third party certification of an exchange platform for credits (Market) which defines minimum criteria to guarantee the concepts of additionality, permanence and baseline, as well as the correct management of the registers of the exchanges made.

Further information

- CARBOMARK – Development of policies for the creation of local voluntary carbon markets for mitigating climate change. https://www.lifegoprofor-gp.eu:9003/goproforlife/best-practice/104/CARBOMARK_Manual_EN.pdf

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ResAlliance

“Resilient Landscapes (RL)”, CIFOR-ICRAF’s private sector facing arm

Connecting science and business for high-impact investments in Nature-based Solutions.



Measuring the tree height with a Vertex hypsometer – Democratic Republic of Congo.
Author: Ollivier Girard | © CIFOR-ICRAF



Landscape view in Nalma village – Nepal.
Author: Mokhamad Edliadi | © CIFOR-ICRAF

/// Context ///

CIFOR-ICRAF is the world’s leading development organization dedicated to terrestrial, coastal and wetland natural capital research. Its mission is to harness the trusted science on forests, trees, and soils with inclusive action to catalyze the transition to more biodiverse forests and farms, climate-resilient communities, vibrant food systems, green and equitable supply and value chains, and rights-based natural resource management.

To achieve this, science needs to support large-scale decisions on ecosystem and landscape management. Capital commitments to these areas are growing but could also lead to the mismanagement of resources if interventions are not science and evidence based. Science-driven Nature-based Solutions (NbS) come to life when the right players understand each other and connect in action. Nature needs funding and funding needs knowledge. As obvious as this is, such synergies do not come about spontaneously.

This is why Resilient Landscapes (RL), a CIFOR-ICRAF initiative, was created to effectively connect the academic, business, and public spheres and accelerate the urgently needed scaling up of investment in sustainable landscapes. RL catalyzes key operational alliances, engaging with key NbS players to propose impact-driven action powered by science. Specifically, the initiative translates science and data into practical business solutions and high impact NbS investment opportunities. RL leverages CIFOR-ICRAF science and evidence to de-risk the financing of NbS projects, by ensuring an improved quality of decision making, which facilitates the flow of capital to the NbS sector, ultimately catalyzing industry-wide advancement.

/// Solution for a Resilient Future ///

Resilient Landscapes (RL) is CIFOR-ICRAF’s private sector facing arm established to leverage science for high-impact NbS investments. Its mission is to catalyse the design, execution, acceleration and learning of large-scale science-based projects specifically tackling the climate crisis, natural capital degradation and biodiversity loss in line with CIFOR-ICRAF’s mission. Through access to CIFOR-ICRAF science and evidence and by connecting these to the private sector, RL helps steer improved quality of decision making at NbS project level. This quality of decisions helps facilitate the flow of capital to the NbS sector, ultimately propelling industry-wide advancement.

More specifically, RL translates science and data into practical business solutions and high-impact green-economy investment opportunities. It primarily focuses on incubating projects that have either emerged from CIFOR-ICRAF’s research portfolio or that come from external sources and can benefit from CIFOR-ICRAF science in the form of information, tools, networks, or methods. Further, RL collaborates with industrial and financial investors seeking to develop NbS projects based on science, and thus to better manage risks and enhance financial and non-financial returns. It connects to all players in the NbS ecosystem, inherently, ensuring that impact is a common language between all NbS project stakeholders and throughout the fields of expertise mobilized by impact investors. The initiative also aims to share risks with investors to achieve a long-term alignment of interests with such partners.

By transforming scientific findings into project designs, RL originates investment opportunities that contribute, in the form of measured impact, to global climate commitments and initiatives. With a global scope, its work may rely on a stronger network in geographies where CIFOR-ICRAF has a ground presence. At project

level, RL systematically connects to the investors' impact targets and indicators. RL analyses impact through the universally endorsed Sustainable Development Goals (SDGs) framework, adapted for private-sector projects.

Resilient Landscapes Luxembourg (RLL)

In 2023, the Ministry of the Environment, Climate and Biodiversity (MECB) of the Grand Duchy of Luxembourg and CIFOR-ICRAF launched the Resilient Landscapes Luxembourg (RLL) Incubator with the mission to accelerate and scale-up investments in sustainable landscapes for urgent climate action. Leveraging CIFOR-ICRAF's science and expertise in forestry, agroforestry, and development, the RLL Incubator focuses on NbS project incubation for environmental resilience. The collaboration builds alliances among corporates, investors, governments, and farmers, with an emphasis on the climate-biodiversity nexus and the SDGs. By showcasing excellence through results, the RLL Incubator aims to demonstrate viability and improved performance of high-impact investment opportunities.



A woman plants an acacia tree – Democratic Republic of Congo.
Author: Fiston Wasanga | © CIFOR-ICRAF



Harvesting cocoa beans in Peru.
Author: Marlon del Aguila Guerrero | © CIFOR-ICRAF

/// Always Moving Forward ///

Under the RLL Incubator, Resilient Landscapes has started the identification, structuring and incubation of impact investment deals through its first projects. By connecting projects to private sector demand and providing project structuring and financial engineering, the RL team is turning ideas into bankable projects with private sector elements which can be scaled up with commercial investments. RLL projects are aligned with CIFOR-ICRAF's mission as well as with Luxembourg's International Climate Finance Strategy. They ensure climate change mitigation, biodiversity enhancement and/or adaptation benefits.

In the coming years, RL aims to leverage impact for NbS. CIFOR-ICRAF, as the world's leading development organization on terrestrial natural capital research together with RL, a team of non-scientists speaking the language of science and business will contribute with its joint knowledge, providing an opportunity to push topics such as 'Business for Biodiversity' and natural capital accounting.

By tapping into CIFOR-ICRAF's collective global research portfolio and network of project developers, RL is ideally positioned to originate, develop, and take to market high-quality science-based terrestrial NbS projects. CIFOR-ICRAF's grounded presence, scientific prowess and technical expertise are RL's greatest assets, which will continue to be leveraged to develop and financially de-risk NbS projects to meet the overwhelming demand from commercial investors. By substantially contributing to the fight against climate change and biodiversity loss in a synergetic way, RL will continue to generate other environmental and social co-benefits. RL environmental, social and governance assessments will be robust and science-based, with clear metrics and impact results to enable the private sector to make real changes for nature and people.

Further information

- Resilient Landscapes Official Website https://resilient-landscapes.org/ (Last access 9 May 2024)
- Resilient Landscapes Luxembourg (RLL) Incubator: https://resilient-landscapes.org/rl-luxembourg/; https://resilient-landscapes.org/rll-press-release-2024/ (Last access 9 May 2024)

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Balancing recreation and conservation: sustainable management of coastal dunes

A community-based framework for the conservation and management of coastal dunes with *Juniperus spp.*



Coastal dunes with Juniperus species, Agios Ioannis, Gavdos Island, Greece.
Author: Ilektra Remoundou | © Educational use, non-commercial.



Coastal dunes with Juniperus species, Kedrodasos, Crete, Greece.
Author: Ilektra Remoundou | © Educational use, non-commercial.

/// Context ///

Coastal dunes with Juniperus spp. are distributed along the sandy coasts of Southern and Western Europe, on Mediterranean and Atlantic coasts. This rare and beautiful habitat features sparse junipers that are prostrate or erect depending on wind action and the adverse conditions typical of sand dunes. This habitat has been classified as a priority habitat by the 92/43 Habitat Directive which means type of habitat in danger of disappearance of which the Community has a particular responsibility for its conservation. Over the last decades, coastal dunes have been subjected to severe anthropogenic pressure and are threatened by: restricted natural regeneration, uncontrolled tourism growth, wood cutting, overgrazing and lack of public awareness.

Coastal dunes are so popular for outdoor recreation which often causes difficult dilemmas in coastal dune management. On one hand, recreation is considered a legitimate and appropriate function of many areas. On the other hand, recreation can result in a loss of the natural qualities and even worse, in a complete destruction of the area. Only through adequate management, nature-based tourism can be a compatible and a complementary land use.

Coastal dunes are so popular for outdoor recreation which often causes difficult dilemmas in coastal dune management.

Dilemmas in coastal dune management.

There is no simple solution to this dilemma. Since many people will continue to visit these habitats and local economies often depend on outdoor activities, it is crucial to mitigate visitors' negative impacts. A community-based approach that integrates conservation, management, and communication activities is key to success. This approach ensures that conservation initiatives focus not only on ecological aspects but also on fostering a sense of stewardship within the community.

The conservation of coastal dunes with Juniperus species requires a multifaceted approach that balances recreational use with habitat protection. By adopting sustainable management practices, promoting responsible visitor behavior and engaging local communities, it is possible to ensure the long-term conservation of these vital ecosystems. This integrated approach not only protects the natural environment but also supports the socio-economic well-being of local communities, creating a sustainable model for coastal dune management.

The conservation of coastal dunes with Juniperus species requires a multifaceted approach that balances recreational use with habitat protection.



Sand traps, Chrysi Island, Greece..
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/// Solution for a Resilient Future ///

The reduction of threats was possible only through a participatory approach, based on the integration of several activities and on an effective and continuous cooperation between all the stakeholders of the project. At the beginning of the project a wide range of stakeholders together defined the threats to the coastal dunes and the actions needed to address them, thus creating a shared framework for – and ownership of – conservation, management and communication activities.

Having examined the biotic and abiotic factors that influence the habitat structure and quality, as well as the effects of anthropogenic pressures, the Junicoast project implemented a range of concrete conservation/ restoration activities and visitors' management practices by applying mild interventions in the field. In addition, seeds and plantlets of the habitat keystone species were collected and conserved ex-situ for their future propagation.

Field restoration and visitor's management infrastructure included:

- Enhancement of Juniperus regeneration through protection of juvenile plants and seedlings, placing light fences around them and producing new plantlets in the nursery from seedlings or cuttings taken from the field.

Integrated management of coastal dunes: active participation and cooperation between all stakeholders.



Discussion with campers, Kedrodasos, Crete, Greece.
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Reduction of threats was possible only through an effective and continuous cooperation between all the stakeholders of the project.

- Restoration of the floristic composition, planting female individuals of Juniperus macrocarpa to balance the sex ratio, eliminating alien species and confining the non-typical plant species having invaded the habitat.
- Foredunes restoration through sand traps to reduce wind erosion, inhibit sand removal and support the formation of embryonic dunes.
- Habitat and trails demarcation, wooden boardwalks information and directional signs to channel the visitors on specific routes, avoid excessive trampling and damage on vegetation throughout the habitat.

More specifically:

- 12 naturally established juveniles of Juniperus macrocarpa have been fenced.
- 184 juvenile Juniperus macrocarpa and other keystone species have been planted in the field.
- 134 individuals of invasive species of Pinus brutia have been removed from all Cretan sites.
- 200 m of sand trapping fences have been constructed.
- 239.31 hectares of coastal dunes with Juniperus spp. have been demarcated in Crete and 327 wooden sticks for habitat demarcation have been installed.
- 340 m of wooden boardwalks have been constructed and installed.
- 16 information signs have been installed.
- 113 directional sticks have been installed along 4.5 km of main trails.
- 30 rubbish bins have been installed and all Cretan habitats have been cleared of litter.



Boardwalk, Chrysi Island, Greece.
Author: Ilektra Remoundou | © Educational use, non-commercial.

Moreover, information about dune systems, their values, characteristics, functions and dynamics were incorporated into a communication strategy to raise public awareness about basic understanding of the nature of dune systems and their role as a sand reserve for the beach.

Public awareness and communication materials included:

- On-site meetings, events and discussions with local communities, visitors and campers.
- Information workshops with environmental educators and tourism representatives.
- Training workshops with stakeholders involved in the protection and management of coastal dunes.
- Education packages for teachers and students (teachers' guide, habitat protection/restoration guidelines.
- Children local events such as student week and guided on-site visits.
- Project website, children's fairy tale, leaflets, posters, notice boards, videos, radio spots and t-shirts.
- Code of conduct for proper visitors' behavior while on-site.

A wide range of stakeholders together defined the threats to the coastal dunes and the actions needed to address them.

More specifically:

- 9 workshops and 20 local events have been organized.
- More than 3.000 school children have been informed and hopefully, motivated.
- 20.000 internet users have been informed.
- 30 articles and news releases have been published in local or National newspapers.
- 20.000 project leaflets, 7.000 project T-shirts and 4.000 copies of the fairy tale have been distributed.
- Radio spot in English and in Greek has been aired 1.472 times.
- The project has been presented 6 times on TV interviews.

/// Always Moving Forward ///

While significant progress has been made in creating a sense of ownership and stewardship over the habitat, continuous efforts and collaborations between all stakeholders are needed in order to enable the long-term conservation of coastal dunes with Juniperus spp.

Regular monitoring and an adaptive management approach should be implemented to improve the resilience of coastal dunes with Juniperus spp. in Crete and the South Aegean. More specifically, regular biodiversity surveys are crucial for tracking target species populations and evaluating the success of restoration efforts. Long-term monitoring protocols to guide management decisions and adjust restoration techniques as needed, should be implemented.

Moreover, conducting research on the potential impacts of climate change on the dunes' system and species composition/structure will help develop strategies to mitigate these impacts. Exploring innovative solutions, including the use of technology for monitoring and management, will enhance the dunes' adaptability to changing environmental conditions.

On the other hand, more research for the development of appropriate decision-making tools/methods is needed. Given that many dune management challenges are completely tied to wider socioeconomic-political trends, governance aspects need to be further addressed in similar future conservation initiatives.

Engaging local communities in all of the above will further promote the sense of ownership and stewardship over the habitat.

During the implementation of the various communication activities, it became clear that people are more inclined to accept restrictions when they know the reasons for the rules.



Coastal dunes – Key message to visitors.
Author: Ilektra Remoundou | © Educational use, non-commercial.

Regular monitoring and an adaptive management approach should be implemented to improve the resilience of coastal dunes with Juniperus spp. in Crete and the South Aegean.

Throughout the project duration and during the implementation of the various communication activities, it became clear that people are more inclined to accept restrictions when they know the reasons for the rules. It became also obvious that the success of conservation and recreation management depends to a large extent on information and environmental education programmes mainly those targeted to the visitors of the sites, the local communities and most importantly to the children. This is very important because not all aspects of coastal dune management are obvious and clear to the public, e.g. stabilization or species protection. Why most importantly to children? Because environmental education is about values, attitudes, ethics and actions. It is a way of thinking and a way of practice. It is our responsibility to equip our children with the attitudes, values, knowledge and skills necessary to rethink and reshape current patterns of action and to secure healthy, just and sustainable future for all.

In summary, the future of nature-based tourism is strongly resource dependent and requires access to high quality natural environments. Safeguarding coastal dunes with Juniperus spp. demands sustained collaboration, informed stewardship, and proactive adaptation to emerging challenges. By prioritizing education, public awareness, implementing rigorous monitoring protocols, and embracing technological advancements, stakeholders can forge a better path towards resilient and sustainable management of these invaluable ecosystems. This integrated approach not only ensures the preservation of biodiversity but also fosters community resilience and promotes harmonious coexistence between human activities and natural habitats.

By leveraging scientific research, adaptive management strategies, and community engagement, we can chart a course towards a future where coastal dunes thrive as resilient ecosystems while sustaining the well-being of local communities and future generations.

Research on the potential impacts of climate change on the dunes' system and species composition/structure will help develop strategies to mitigate these impacts.

Further information

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- Layman's report. Actions for the conservation of coastal dunes with Juniperus spp. in Crete and the South Aegean (Greece). URL: http://www.junicoast.gr/documents/0000/0177/LIFE_07_NAT_GR_000296_Deliverable_D.6.2_EN.pdf
- Final project report. Actions for the conservation of coastal dunes with Juniperus spp. in Crete and the South Aegean (Greece). URL : http://www.junicoast.gr/documents/0000/0200/LIFE07NATGR000296_JUNICOAST_FINAL_REPORT.pdf

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Partners: CIHEAM – MAICH – Mediterranean Agronomic Institute of Chania

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Type of solution: Management Sector: Forestry

Good practice(s): Management alternatives, Community engagement, Protection against biotic and abiotic hazards

Conservation of Coastal Dunes with *Juniperus spp*. in Greece

A community-based framework for the conservation and management of coastal dunes with Juniperus spp.



Coastal dunes with Juniperus species, Agios Ioannis, Gavdos Island, Greece.
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Discussion with campers, Agios Ioannis, Gavdos Island, Greece.
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/// Context ///

Coastal dunes with Juniperus spp. have been classified as a priority habitat by the 92/43 Habitat Directive which means type of habitat in danger of disappearance of which the Community has a particular responsibility for its conservation. Coastal dunes are so popular for outdoor recreation which often causes difficult dilemmas in coastal dune management. On one hand, recreation is considered a legitimate and appropriate function of many areas. On the other hand, recreation can result in a loss of the natural qualities and even worse, in a complete destruction of the area. Only through adequate management, nature-based tourism can be a compatible and a complementary land use. Over the last decades, coastal dunes have been subjected to severe anthropogenic pressure and are threatened by: restricted natural regeneration, uncontrolled tourism growth, wood cutting, overgrazing and lack of public awareness. Since many people will continue to visit the habitats and since the economy of local communities is based on outdoor activities, more effort is needed to mitigate the visitors' impacts on those sites. Achieving the ecological objective of the project was supported by working on the human dimension of ecosystem degradation, addressing the dune users and the local communities. In such, a community-based approach focused on the integration of conservation, management and communication activities and on continuous cooperation between all the stakeholders of the project was adopted.

/// Solution for a Resilient Future ///

The reduction of threats was possible only through a participatory approach, based on the integration of several activities and on an effective and continuous cooperation between all the stakeholders of the project. At the beginning of the project a wide range of stakeholders together defined the threats to the coastal dunes and the actions needed to address them, thus creating a shared framework for – and ownership of – conservation, management and communication activities.

Having examined the biotic and abiotic factors that influence the habitat structure and quality, as well as the effects of anthropogenic pressures, the Junicoast project implemented a range of concrete conservation/ restoration activities and visitors' management practices by applying mild interventions in the field. In addition, seeds and plantlets of the habitat keystone species were collected and conserved ex-situ for their future propagation.

Field restoration and visitor's management infrastructure included:

- Enhancement of Juniperus regeneration through protection of juvenile plants and seedlings, placing light fences around them and producing new plantlets in the nursery from seedlings or cuttings taken from the field.
- Restoration of the floristic composition, planting female individuals of *Juniperus macrocarpa* to balance the sex ratio, eliminating alien species and confining the non-typical plant species having invaded the habitat.
- Foredunes restoration through sand traps to reduce wind erosion, inhibit sand removal and support the formation of embryonic dunes.

- Habitat and trails demarcation, wooden boardwalks and directional signs to channel the visitors on specific routes, avoid excessive trampling and damage on vegetation throughout the habitat.

Moreover, information about dune systems, their values, characteristics, functions and dynamics were incorporated into a communication strategy to raise public awareness about basic understanding of the nature of dune systems and their role as a sand reserve for the beach.

Public awareness and communication materials included:

- On-site meetings, events and discussions with local communities, visitors and campers.
- Information workshops with environmental educators and tourism representatives.
- Training workshops with stakeholders involved in the protection and management of coastal dunes.
- Education packages for teachers and students (teachers' guide, habitat protection/restoration guidelines).
- Children local events such as student week and guided on-site visits.
- Project website, children's fairy tale, leaflets, posters, notice boards, videos, radio spots and t-shirts.
- Code of conduct for proper visitors' behaviour while on-site.



Sand traps, Chrysi Island, Greece.
Author: Ilektra Remoundou | © Educational use, non-commercial.



Fencing Juniperus young individuals, Kedrodasos, Greece.
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/// Always Moving Forward ///

It is obvious that continuous efforts and collaborations between all stakeholders are needed in order to enable the long-term conservation of coastal dunes with *Juniperus* spp.

Throughout the project duration and during the implementation of the various communication activities, it became clear that people are more inclined to accept restrictions when they know the reasons for the rules. It became also obvious that the success of conservation and recreation management depends to a large extent on information and environmental education programmes mainly those targeted to the visitors of the sites, the local communities and most importantly to the children. Why most importantly to children? Because environmental education is about values, attitudes, ethics and actions. It is a way of thinking and a way of practice. It is our responsibility to equip our children with the attitudes, values, knowledge and skills necessary to rethink and reshape current patterns of action and to secure healthy, just and sustainable future for all.

Last but not least, regular monitoring and an adaptive management approach should be implemented to improve the resilience of coastal dunes with *Juniperus* spp. in Crete and the South Aegean.

Further information

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Forest landscape restoration in the Shouf Biosphere Reserve, Lebanon.

Pilot actions integrating social needs and ecological restoration through a community-driven approach



Low mountain pasture, including abandoned agriculture terraces at the Shouf Biosphere Reserve.
Author: Shouf Biosphere Reserve team and Pedro Regato | © Educational use, non-commercial.



Land degradation in a sandstone quarry.
Author: Shouf Biosphere Reserve team and Pedro Regato
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/// Context ///

The landscape in the Shouf Biosphere Reserve has been under unsustainable use for many years. Deteriorating soils and lack of local employment led many households to migrate for work, sending remittances back home, leading to a sharp increase in mining and building houses. These challenges caused a decline in traditional cultural practices and customary governance around land use. In particular, farmers abandoned terraced farming which led to additional soil degradation and reduced water retention. The rise in mining and building houses further displaced agricultural and forest lands.
Since 2005, the management team of the reserve has taken proactive steps to engage stakeholders in planning and visioning. Their goal has been to align environmental, social and economic objectives to show that ecological and social benefits can be achieved simultaneously. They initiated pilot actions such as planting native trees, restoring abandoned terraces, constructing dry-stone walls and managing biomass. These efforts were based on the concept of forest and landscape restoration. All pilot actions were implemented on public and private lands, in areas that were most appropriate for each based on participatory mapping and planning. Overall, they were used to illustrate a proactive approach to environmental restoration while fostering local economic opportunities and advocating for supportive policy changes for future interventions.

/// Solution for a Resilient Future ///

Several pilot actions (2 to 6) aimed at planting native trees to achieve various ecological goals. Trees were planted in a staggered (quincunx) pattern at densities of 500-800 seedlings per hectare to enhance water retention and reduce runoff. Initial plantings in 2014 faced high mortality due to drought and predation, leading to replanting with improved seedlings in 2015. Survival rates after 3 years ranged from 75%-99%.

Pilot actions included:

Pilot 1 – Improving nursery management
Improved nursery management techniques led to stronger root systems in seedlings, minimizing the need for extra watering and reducing restoration costs. Improved methods were later adopted in national forest restoration plans.

Pilot 2 – Creating connectivity between isolated cedar stands
Oak acorns were planted to connect isolated cedar stands, aiming to enhance cedar growth by reducing solar radiation, improving soil and water retention, shielding young cedars from herbivores and serving as nurse logs. The use of plastic tubes protected the acorns from rodents; allowing good germination and growth with a survival rate of 70-80%.

Pilot 3 – Enhancing tree and shrub diversity in high mountain forest and facilitating upward climate-induced migration

High mountain forest habitats were reforested with diverse tree and shrub species to help forest ecosystem recovery. After 3 years, seedling survival rate was around 90%.

Pilot 4 – Establishing “tree islands” for applied nucleation in overgrazed areas
“Woodland islets” featuring diverse species were established in overgrazed areas, achieving a 95% survival rate. This pilot showed its positive impacts on biodiversity and local livelihoods through supporting ecological succession.

Pilot 5 – Restoring vegetation to abandoned quarry
Abandoned limestone quarry slopes were afforested. Both directly sown seeds and seedlings successfully controlled erosion. After 3 years, seedling survival rates were high (85-95%).

Pilot 6 – Restoring wetlands and diversifying wetland forests
This pilot was carried out in collaboration with private

vineyard and fruit tree crop owners near the Ammiq wetland. After 3 years, planted trees had a survival rate of > 95%, aided by controlling grazing and watering seedlings.

Pilot 7 – Restoring agriculture terracing
Abandoned agricultural terraces were restored to cultivate fruit, olives, nuts, herbs, aromatic plants and other local crops. The restoration process involved removing loose stones, digging drainage systems at the wall bases and rebuilding with reclaimed and new stones. Compost from waste biomass was added to the soil. Seedlings were planted while preserving natural forests and shrubs.

Pilot 8 – Reducing fire risks by managing forest biomass
Biomass reduction involved thinning and pruning Quercus calliprinos and Pinus brutia forests along high-risk roads to reduce fire risks. Positive results led to policy changes in fire prevention.

Pilot 9 – Alternative energy and waste management
This pilot included setting up a briquette production plant and composting factory to utilize waste biomass effectively; creating jobs, reducing pollution, and improving forest resilience.



Restoring forest land. Enhancing tree and shrub diversity.
Author: Shouf Biosphere Reserve team and Pedro Regato | © Educational use, non-commercial.



Dry stone wall restoration.
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/// Always Moving Forward ///

The Shouf Biosphere Reserve has made significant progress in integrating social needs with ecological restoration. Key steps for sustainability include:

1. Continued monitoring and innovation
   - Maintain ongoing monitoring of ecosystem recovery and survival rates
   - Assess connectivity and long-term impact of oak and cedar stands
   - Conduct periodic habitat quality assessments
   - Evaluate the benefits of restored vegetation and erosion control
   - Explore innovative monitoring and management solutions
2. Community engagement and capacity building
   - Strengthen partnerships with private landholders and local communities
   - Showcase successes to gain community support
   - Share lessons from pilot actions for future projects
   - Invest in training programs for sustainable practices
3. Scaling up successful practices
   - Expand techniques like nursery improvements and species-diverse woodlands
   - Explore partnerships for initiatives like briquette production and composting
   - Use successful outcomes to advocate for supportive policies
4. Long-term sustainability, climate change and resilience
   - Prioritize practices that enhance ecosystem resilience against climate change
   - Advocate for biomass management to reduce fire risks
   - Promote policies for long-term forest restoration and sustainable land use

Further information

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Balancing social needs and ecological forest restoration in the Shouf Biosphere Reserve, Lebanon

Integrating social, economic and ecological benefits through community-driven Forest and Landscape Restoration.



Mixed forests of Lebanese cedar and Brant's oak in the Shouf Biosphere Reserve.
Author: Shouf Biosphere Reserve team and Pedro Regato
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From left to right: Abandonment of the traditional terraced farming systems; Uncontrolled house building: Opening of quarries for stone and sand extraction.
Author: Shouf Biosphere Reserve team and Pedro Regato
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/// Context ///

The landscape in the Shouf Biosphere Reserve has been under intense and growingly unsustainable use for many years. Deteriorating soils and lack of local employment led many households to migrate for work and send home remittances leading to a sharp increase in mining and building houses. These challenges led to the loss of traditional cultural practices and customary governance around land use. In particular, farmers abandoned terraced farming, which led to soil degradation and reduced water retention. Moreover, the increase in mining and building houses further displaced agricultural and forest lands.

As the management body of the reserve began to engage stakeholders in visioning and planning (2005 onwards), it became clear that social rather than environmental issues, were front of mind for many. Key concern was to address pressing local needs and to demonstrate that both ecological and social benefits can be achieved simultaneously. Stakeholders sought to find synergies between environment, social, and economic benefits. For example, and because fire was a major concern, biomass management was used as an entry point for engaging people. Creating local businesses to use extra biomass to produce briquettes was another entry point: it created job opportunities, reduced diesel consumption and cost of energy; demonstrating that daily needs could be met and improved through conserving, managing and restoring the landscape.

Challenges of unsustainable land use in the Shouf Biosphere Reserve.

Stakeholders key concern was to address pressing local needs and to demonstrate that both ecological and social benefits can be achieved simultaneously.

Pilot actions (planting trees, restoring abandoned terraces, constructing dry stone walls, managing biomass etc.) based on the concept and principles of forest and landscape restoration (FLR) were crucial to engage stakeholders to build support for restoration activities. They were designed to demonstrate tangible results; each involved generating social, ecological and economic benefits. They were implemented on public and private lands, in areas that were most appropriate for each based on participatory mapping and planning. All pilot actions demonstrated that restoration is not necessarily costly but can be a viable "business". They included a financial plan to show what the return would be in several years. They were also used to demonstrate how policies should be altered to better support FLR interventions moving forward.

Intervention measures, based on the concept and principles of forest and landscape restoration, were crucial to engage stakeholders and local communities to build support for restoration activities.

/// Solution for a Resilient Future ///

Pilot actions (2 to 6) aimed at planting native trees to achieve various ecological goals. Trees were planted in a staggered (quincunx) pattern at densities of 500-800 seedlings per ha to enhance water retention and reduce runoff. Initial plantings in 2014 faced high mortality due to drought and predation, leading to replanting with improved seedlings in 2015. Survival rates after 3 years ranged from 75%-99%.

Pilot actions included:

Pilot 1 – Improving nursery management

Standard nursery trees initially had weak root systems and low survival rates. Nursery staff developed methods to grow seedlings with stronger root systems, enabling them to withstand summer droughts. This showed that forests could be restored without extra watering, reducing costs. Enhanced methods were later adopted in national forest restoration plans.

Pilot 2 – Creating connectivity between isolated Lebanese cedar (*Cedrus libani*) stands

A 6 hectares area at 1800 masl was planted with Brant's oak (Quercus brantii) acorns to show that oak forests can link remnant Lebanese cedar stands. Oaks help cedar growth by reducing solar radiation, improving soil and water retention, shielding young cedars from herbivores and serving as nurse logs. The use of plastic tubes protected the acorns from rodents; allowing good germination and growth with a survival rate of 70-80%.

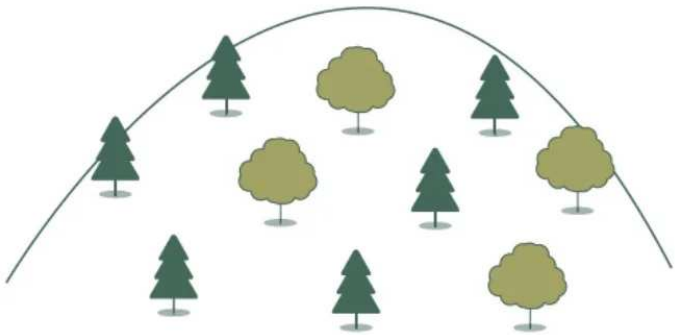
Pilot 3 – Enhancing tree and shrub diversity in high mountain forest and facilitating upward climate-induced migration

A 20 hectares site with steep limestone slopes, bare rock and abandoned terracing; located at elevations between 1750 – 1925 masl, was restored. The area had sparse vegetation including grass, low shrubs and small trees. Restoration involved planting seeds and seedlings of dominant tree species and companion shrubs to help forest ecosystem recovery. After 3 years, seedling survival rate was ~ 90%.

Pilot 4 – Establishing "tree islands" for applied nucleation in overgrazed areas

Species-diverse woodland islets were planted on overgrazed pastures to enhance drought summer conditions and to support ecological succession through shade and seed sources. Seedlings had a 95% survival rate without irrigation. This technique demonstrated to the community, including shepherds, that tree planting could restore degraded pastures, enhance biodiversity, improve livestock production and benefit local livelihoods.

Balancing social needs and ecological forest restoration in the Shouf Biosphere Reserve, Lebanon.



Quincunx pattern of planting trees to maximize water retention on slopes (the curved line represents the top of a hill or mountain).
Author: Shouf Biosphere Reserve team and Pedro Regato
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Restoration efforts involved planting seeds and seedlings of dominant tree species and companion shrubs to aid in forest ecosystem recovery.

Pilot 5 – Restoring vegetation to abandoned quarry

This pilot aimed to demonstrate effective restoration techniques at an abandoned limestone quarry. After 3 years, seedling survival rates were high (85-95%). Both directly sown seeds and seedlings successfully controlled erosion.

Pilot 6 – Restoring wetlands and diversifying wetland forests

This pilot was carried out in collaboration with private vineyard and fruit tree crop owners near the Ammiq wetland. After 3 years, planted trees had a survival rate of > 95%, aided by controlling grazing and watering seedlings. This pilot showed that private landholders can effectively manage wetland and riparian areas, highlighting the benefits of riparian forest conservation and restoration for sustaining agricultural production and clean water supply.

Pilot 7 – Restoring agriculture terracing

A 150 hectars of abandoned terraces were restored to cultivate fruit, olives, nuts, herbs, aromatic plants and other local crops. Traditional dry-stone walls were rebuilt to prevent erosion and retain water. The restoration process involved removing loose stones, digging drainage systems at the wall bases and rebuilding with reclaimed and new stones. Compost from waste biomass was added to the soil. Seedlings were planted while preserving natural forests and shrubs. This pilot showcased that abandoned land could become productive again, improving environmental conditions and providing additional income.

Native trees were planted at densities of 500-800 seedlings per ha in a staggered (quincunx) pattern to enhance water retention and reduce runoff on slopes.





Restoring traditional dry-stone walls prevent erosion, retain water, boost biodiversity and benefit local livelihoods.

From left to right: Rodent activity in the soil of restoration sites; Sowing of Branti oak acorns with protector to prevent rodent predation.
Author: Shouf Biosphere Reserve team and Pedro Regato
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Pilot 8 – Reducing fire risks by managing forest biomass

Fires were common in the SBR, particularly in autumn when farmers burned crop waste. Piloted biomass reduction involved thinning and pruning Quercus calliprinos and Pinus brutia forests along high-risk roads, yielding promising results. Positive results prompted a policy shift, expanding the use of these techniques. Local landholders showed willingness to replicate this activity on their land.

Pilot 9 – Alternative energy and waste management

This pilot included setting up a briquette production plant and composting factory to utilize waste biomass effectively; creating jobs, reducing pollution, and improving forest resilience.



Sustaining and expanding restoration efforts in the Shouf Biosphere Reserve.

The nursery effect of Quercus brantii facilitating the growth of Cedrus libani.
Author: Shouf Biosphere Reserve team and Pedro Regato
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/// Always Moving Forward ///

While substantial progress has been made in integrating social needs and ecological restoration in the Shouf Biosphere Reserve, several strategic steps and continuous collaboration between all stakeholders is needed in order to consolidate gains and to ensure the long-term success and sustainability of the restoration activities.

By advancing the following steps, the Forest and Landscape Restoration initiative in the Shouf Biosphere Reserve, can address and overcome future challenges, consolidate gains from its pilot actions, pave the way for broader adoption of successful strategies in forest restoration and sustainable land management and contribute to broader environmental conservation and sustainable development goals in the region.

1. Continued monitoring/evaluation, adaptive Management and innovation

- Maintain ongoing monitoring of survival rates and ecosystem recovery to adapt management practices based on ongoing results
- Continue monitoring the connectivity between oak and cedar stands and assess the long-term impact on cedar growth and biodiversity enhancement
- Conduct periodic assessments of habitat quality, including vegetation health, wetland water quality and integrity of dry-stone walls
- Evaluate the ecological benefits of restored vegetation on steep limestone slopes
- Evaluate the effectiveness of seedling survival rates and erosion control techniques in other quarry sites
- Explore innovative solutions such as technology-enabled monitoring and management to enhance adaptability to changing environmental conditions
- Promote innovation in alternative energy and waste management to reduce reliance on traditional energy sources and enhance sustainability

2. Community/stakeholder engagement and capacity building

- Strengthen partnerships with private landholders and local communities to ensure sustained management and success of restoration areas
- Showcase successes to gain community support and participation in future efforts



From left to right: General model of terrace system; Restored agricultural terraces planted with herbs, olives and native fruit trees.
Author: Shouf Biosphere Reserve team and Pedro Regato
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From left to right: Fuel reduction treatments (reduction of ladder fuels up to 2 meters, Pinus brutia); Oak thinning; Biomass shredding machine.
Author: Shouf Biosphere Reserve team and Pedro Regato
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- Share lessons learned from each pilot action to inform future initiatives locally and regionally
- Invest in training programs for nursery managers, community leaders, and forestry officials to enhance local capacity in sustainable forest management practices

3. Scaling up successful practices

- Work with local communities to identify additional sites for similar interventions
- Expand effective techniques like nursery improvements, protective measures, establishment of species-diverse woodland islets in overgrazed areas and diversified planting strategies wherever feasible
- Explore partnerships with local businesses and communities to replicate initiatives such as briquette production and composting
- Use successful outcomes to advocate for supportive policies and broader adoption by governmental and community stakeholders

4. Long-term sustainability, climate change and resilience

- Identify where FLR initiatives can incur net benefits for biodiversity conservation and human wellbeing so that restoration efforts can be effectively targeted (cost-benefit analysis of FLR initiatives)
- Prioritize practices that enhance ecosystem resilience against climate change impacts, such as water retention and biodiversity enhancement
- Advocate for broader implementation of biomass management techniques to reduce fire risks
- Advocat e for policies that endorse long-term forest restoration and sustainable land use practices, ensuring integration into broader environmental and economic planning




From left to right: Briquettes produced from thinned biomass and olive pomace; Compost production for agricultural use.
Author: Shouf Biosphere Reserve team and Pedro Regato
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Continuous collaboration between all stakeholders is needed in order to consolidate gains and to ensure the long-term success and sustainability of the restoration activities.

Restoration is an iterative process. This process is both learning by doing and also learning by research - Research as part of the learning process is a must.

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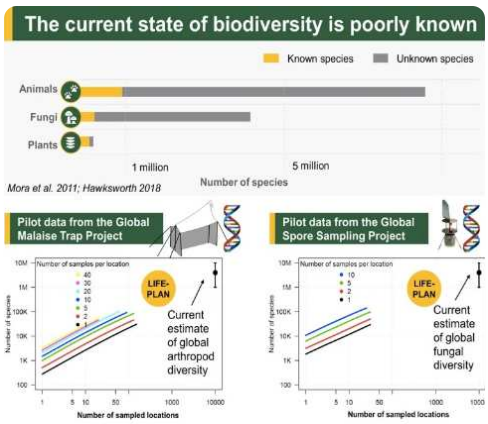
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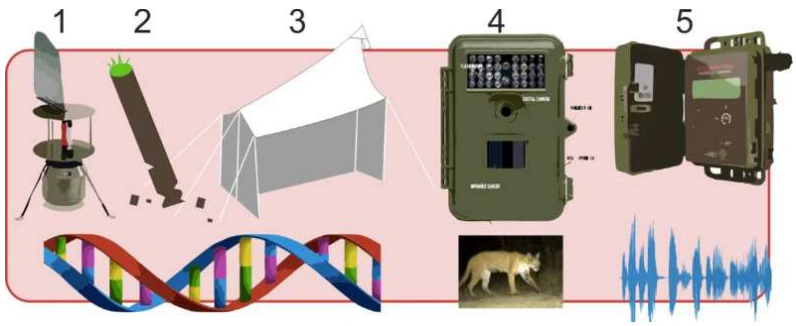
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Big ecological data collection and analysis for a global synthesis of biotic patterns

In Lebanon, under the LIFEPLAN project, biodiversity-related information is being collected with innovative methodologies.



Current status of biodiversity.
Author: LIFEPLAN project. | © Educational use, non-commercial.



Different monitoring stations.
Author: LIFEPLAN project. | © Educational use, non-commercial.

/// Context ///

Understanding biodiversity patterns is essential for any sustainable management of natural resources, especially in the face of ongoing global change. Our lack of knowledge extends beyond global species richness to the way species form communities and interact within ecosystems. Current knowledge often relies on fragmented data, gathered through varying approaches, which provide an incomplete picture. Also, many studies focus on only a small portion of the overall diversity, often overlooking the complex interactions and behaviors that shape ecosystems. This gap in understanding poses two major challenges: a lack of comprehensive data on most species and the intricate dynamics that drive biodiversity. Both are crucial to developing effective restoration programs which ultimately will contribute to long-term landscape resilience.

The LIFEPLAN initiative seeks to bridge this gap by bringing together experts in community ecology, automated species recognition, and advanced statistical methods to generate and analyze Big Ecological Data on a global scale. By using semi-automated, standardized methods, the project aims to create comparable data across a wide range of species, offering a more complete understanding of biodiversity patterns. Global collaboration is key, and Lebanon, through the “Genomic Characterization of Plants” laboratory at Saint Joseph University (USJ), is contributing to this effort, working to assess and better understand local biodiversity.

Accounting for biodiversity patterns is the basis for any sustainable management of natural resources in the face of ongoing global change.

By using five sampling methods from different stations installed in Wadi Quadisha (natural) and Mrouj (urban), biodiversity data is collected, including fungal spores sampling, insect trapping, camera trapping captures images of mammals and birds or audio recording of birds and bats. A deeper understanding of species’ ecological behaviors and interactions will not only improve biodiversity knowledge but also lead to more accurate restoration efforts and stronger landscape resilience in the long term.

The importance of understanding how different species interact.

Understanding how species are structured into communities and how they interact with each other.

/// Solution for a Resilient Future ///

There are two main reasons why we understand biodiversity and its drivers so poorly. First, we lack the relevant data, since for the vast majority of species we have either no data or very sporadic data. Second, the processes underlying biodiversity dynamics are complex, and we lack the tools for converting the data that we have into a true understanding of the processes behind them. Through the LIFEPLAN project, we will overcome both hurdles. The project brings together the key expertise needed to generate and interpret Big Ecological Data for a global synthesis of biotic patterning across our planet uniting community ecology, methods for automated species recognition, and Bayesian statistics for immense data. As a basis for the whole project, the project will generate a well-standardized global data for a substantial proportion of all species. Such standardization is achieved through semi-automated methods, producing comparable data independent of the exact expertise of the person or team conducting the sampling. Based on a recent revolution in sampling methodology, such a sampling design is now finally achievable.

In LIFEPLAN we use five sampling methods, each appropriate to the type of variable being considered: i) Cyclone sampling – to collect fungal spores, ii) Malaise trapping – to collect insects, iii) Soil sampling – to collect soil for fungal DNA, iv) Camera trapping – to capture images of mammals and birds, v) Audio recording – to capture bird and bat sounds.

The LIFEPLAN sampling scheme contains 83 global locations, 44 national locations. The only difference between the global and national sampling schemes is that at the global scale, we will also explore the impacts of urbanization. Hence, for each of the 83 locations spread across the world, we switch between an urban and a natural location on a yearly basis, whereas at the national level, locations remain fixed.



Malaise trap.
Author: Jouzour Loubnan | © Educational use, non-commercial.

The Lifeplan project, financially supported by Jouzour Loubnan Association, holds the potential to unravel, illuminate, and protect Lebanese biodiversity.

The Mediterranean region, including Lebanon, is recognized as a biodiversity hotspot, holding some of the most biologically rich yet threatened areas on Earth. Lebanon, situated at the crossroads of three continents, serves as a hub for Eastern Mediterranean Region (EMR) biodiversity and is acknowledged as a regional hotspot. The country's diverse ecosystems result from its geographical location and complex geomorphology, providing a mosaic of habitats for flora and fauna. Lebanon acts as either the southernmost or northernmost distribution limit for numerous European and African plant and animal species, making it a hybridization zone for many organisms from the surrounding continents.

The two main locations in Lebanon where the different monitoring stations are installed are Wadi Quadisha (natural) and Mrouj (urban). Kadisha Valley, Lebanon's natural LIFEPAN site, is identified as an Important Plant Area (IPA) and a UNESCO World Heritage site due to its cultural landscape. The valley, located opposite Saint Antonio's monastery, holds thousands of flora and fauna

Installation of different monitoring stations to assess biodiversity.

Cyclone sampling collects fungal spores, Malaise trapping collects insects and soil sampling collects soil which we sample for fungal DNA.



species, many of which are endemic to Lebanon or the region. With altitudes ranging from 960 m to 990 m, the site represents a typical mixed Mediterranean forest, woodland, and scrub, dominated by pines and oaks. Our research team at Saint-Joseph University of Beirut, in collaboration with field coordinators and Jouzour Loubnan Association, is conducting biodiversity assessments in Lebanon.

Camera trapping captures images of mostly mammals and birds, and audio recording captures bird and bat sound.

Sciurus anomalus caught on camera.
Author: Jouzour Loubnan | © Educational use, non-commercial.

Despite limited assessments due to governance issues and funding deficiencies, Lebanon's selection for the LIFEPLAN initiative aims to enhance bioliteracy by providing tools for local biodiversity identification and understanding. The LIFEPLAN project, financially supported by Jouzour Loubnan Association, holds the potential to unravel, illuminate, and protect Lebanese biodiversity. The team eagerly anticipates the results and hopes that LIFEPLAN will significantly contribute to a deeper understanding of Lebanon's biodiversity on a global scale.

/// Always Moving Forward ///

Our commitment to the future sampling effort includes:

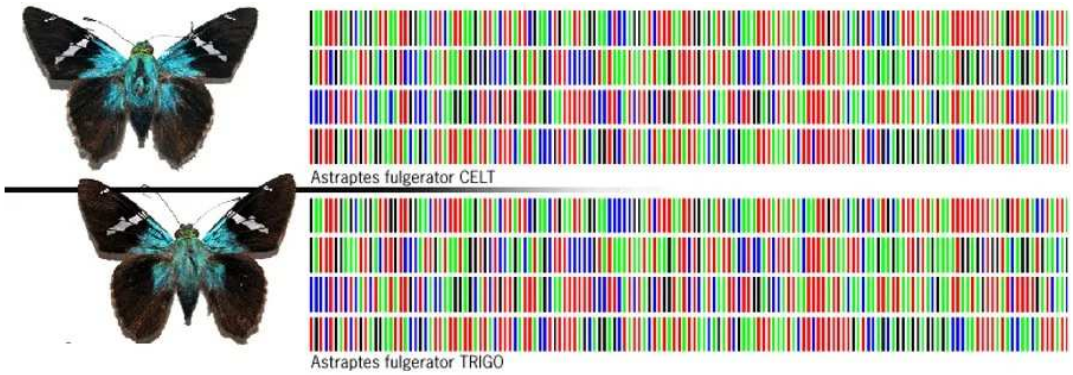
- Installing a Malaise trap, cyclone sampler, three cameras, and three audio samplers (attached to trees).
- Conducting yearly transfers of all sampling equipment between natural and urban locations or vice versa (for 6 years).
- Collecting four soil samples, four times a year during the growing season.
- Performing weekly tasks such as changing batteries on all devices (the Cyclone sampler operates on a car battery that needs bi-weekly replacement), changing sampling tubes on the cyclone sampler and Malaise trap, changing memory cards on audio samplers and cameras, and logging and labeling samples.

Upon analyzing the photographs captured by the camera traps, we have successfully identified at least seven distinct species, including the Golden jackal (Canis aureus), red fox (Vulpes vulpes), wild cat (Felis silvestris), Indian crested porcupine (Hystrix indica), beech marten (Martes foina), squirrel (Sciurus anomalus), and wild boar (Sus scrofa). Some of these images are provided below for reference.

In the audio recordings, a bird expert is currently annotating soundscapes on the global bird sounds portal, a platform that employs automated species recognition through machine learning. This annotation process will contribute to the creation of a model that, once completed, will enable us to upload our audio recordings for automated bird identification using a finely-tuned AI model tailored to Lebanon.

As we progress through the six-year project, one of our key objectives will be to conduct a thorough comparative analysis of biodiversity in urban versus natural sites. This analysis will specifically focus on the differences between the urban site in Mrouj and the natural site in Wadi Quadisha. By examining

Understanding interactions and potential scenarios contribute to the development of effective conservation strategies.



Barcoding of Insects.
Author: LIFEPLAN project.
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these two distinct environments, we aim to assess the impact of urbanization on biodiversity. This study will provide critical insights into how urban development influences various species and ecosystems, revealing patterns and trends that can inform future urban planning and conservation efforts.

Beyond the comparative analysis, our project will also make a significant contribution to the preparation of a comprehensive national checklist of animals, birds, and fungi in Lebanon. This checklist will serve as a foundational resource for researchers, conservationists, and policymakers, offering a detailed account of Lebanon's biodiversity. The creation of this checklist is a vital step towards documenting and understanding the country's biological heritage, which is essential for effective conservation and management.

Moreover, the extensive data collected throughout this project will play a crucial role in enhancing our understanding of the interactions between different species within the ecosystem. By studying these interactions, we can gain insights into the complex web of relationships that sustain biodiversity. This knowledge is critical for identifying future potential scenarios for biodiversity, particularly in the face of various threats such as climate change, habitat loss, and pollution.

Understanding these interactions and potential scenarios will enable us to develop more effective conservation strategies. We will be better equipped to anticipate and mitigate the impacts of these threats, ensuring the long-term health and resilience of Lebanon's natural environments. Our findings will not only benefit local biodiversity but also contribute to global efforts in biodiversity conservation.

Ultimately, this project aims to foster a deeper understanding and appreciation of Lebanon's rich biodiversity. By integrating scientific research with practical conservation efforts, we hope to create a sustainable future where both urban and natural ecosystems can thrive.

The project will also make a significant contribution to the preparation of a comprehensive national checklist of animals, birds, and fungi in Lebanon.

Several factors showed a positive effect on seed cone production in Aleppo pine natural forest growing in North Africa.

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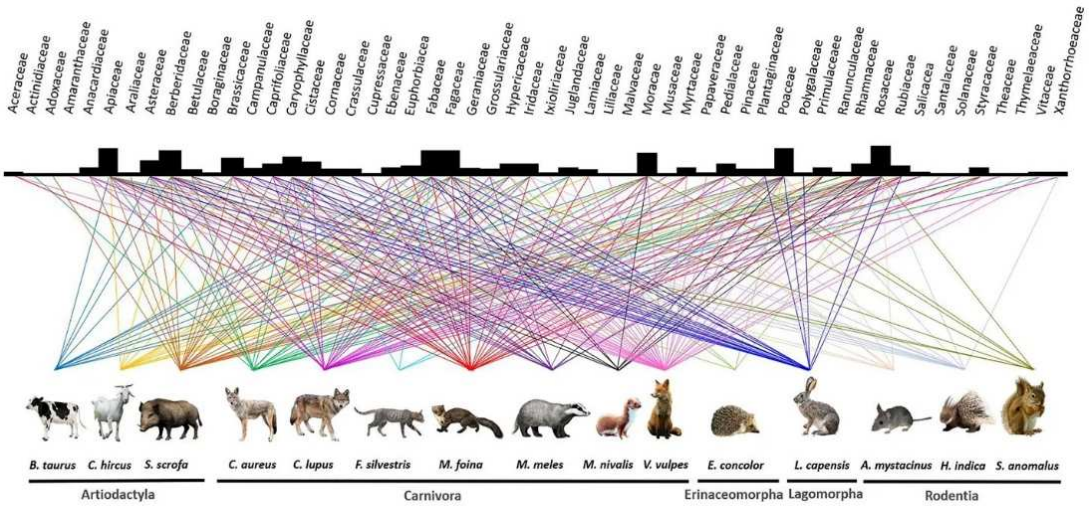
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DNA analysis on scats to understand animals diet: a tool for ecological restauration in Mount Lebanon

Understanding the ecological interactions between animals and plants can increase the effectiveness of ecosystem restoration.



Diet analysis of different animals.
Author: Rhea Kahale
© Jouzour Loubnan

/// Context ///

Species longevity depends largely on interactions between animals and plants within an ecosystem, such as predation and seed dispersal, which are key to species conservation. Diet analysis is a fundamental tool for evaluating these interactions, crucial for identifying conservation targets and implementing effective reforestation and restoration.

Understanding predator-prey dynamics and seasonal food web variations offers insight into ecosystem structure and function. Seed dispersal, a vital plant-animal mutualism, allows plants to reproduce and maintain ecosystem sustainability. For forest managers, knowing which plant species animals consume and disperse is essential for reforestation and wildlife conservation.

In Lebanon, reforestation projects have primarily used monocultures, such as cedar and pine, which, while productive, may not maximize ecosystem resilience. A better approach involves planting species that support wildlife, particularly seed dispersers, to accelerate natural regeneration and enhance forest recovery. To address this, we are developing a DNA reference library to better understand and guide these interactions for more effective restoration programs.

/// Solution for a Resilient Future ///

The animal component in ecological restoration projects often receives insufficient attention, despite the undeniable importance of animals as pollinators and seed dispersers. By examining animal scats and analyzing their seed content, we gain direct insight into seed dispersal patterns. However, identifying the animals responsible for these scats can be as challenging as identifying plant species based on their seeds. Consequently, employing DNA analysis on scats can provide valuable information for constructing the forest's food web by revealing the dietary habits of animals throughout each season.

The sustainability of a restored ecosystem hinges heavily on its animal inhabitants. But who are these animals? Are they still present in the vicinity of the restored area? Has their frequency and population increased following the restoration project? Through the innovative technique of DNA metabarcoding, we've delved into the genetic data concealed within animal scats.

The combination of noninvasive sampling methods and genetic scat analysis has proven to be a potent tool for species detection. Indeed, the crucial information required to study animal diets lies within their scats, containing not just the animal's DNA but also evidence of the species it has consumed. The DNA sequences extracted from such material are cross-referenced with a reference library of animals and plants native to the Eastern Mediterranean countries. In fact, we have constructed the first reference library of animal and plant species of Lebanon. This library is crucial since the existing data on biodiversity in the Middle East region are poor and sporadic; vary from one species to another. The assessment of species' biodiversity and the dynamic of its population is indispensable especially for animals and the plant species that they consume.

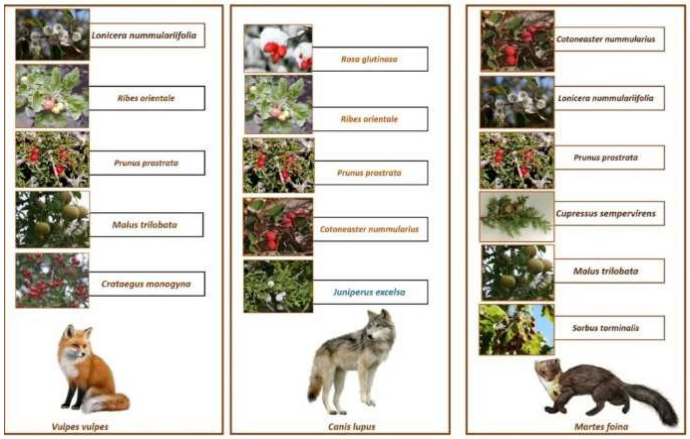
The results are very promising for Lebanon and the

region. The reference library will be posted on international data base platforms. A total of 18 mammal species have been identified, providing valuable insights into their diets. Many of these animal species are endemic to the region and/or face threats, particularly in Lebanon. This research has enabled us to assess species richness and implement targeted conservation and management strategies for species of concern. In Lebanon, carnivores have emerged as significant frugivores and seed dispersers. Families such as Apiaceae, Berberidaceae, Fabaceae, Fagaceae, Poaceae, and Rosaceae are among the most consumed by these animals. Planting these species will not only attract wildlife to Lebanese forests but also contribute to the preservation of Mediterranean biodiversity. This work reinforces the fundamental principle of restoration ecology, emphasizing the importance of planting a diverse array of native species to foster and safeguard thriving wildlife populations.



Mount Lebanon landscape.
Author: Saint Joseph University | © Educational use, non-commercial

Figure 8: Plants seeds dispersersed by *Vulpes vulpes*, *Canis lupus* and *Martes foina*



Plant seed dispersed by Vulpes vulpes, Cais lupus and Martes foina.
Author: Rhea Kahale | © Jouzour Loubnan

/// Always Moving Forward ///

Moving forward, we propose key strategies to enhance the ecological restoration efforts.

- Consider a broaden scope to include birds. Birds, like mammals, play crucial roles in ecosystems through seed dispersal, insect control, and pollination. Including birds in restoration plans can improve ecosystem resilience and biodiversity.
- Use of DNA Analysis. Analyzing bird and mammal diets through scat DNA helps tailor restoration to support species that enhance ecosystem functioning
- Creation of complementary niches. Birds and mammals occupy different niches, providing complementary effects on vegetation and ecosystem dynamics. Restoration plans should reflect this diversity and consider distinct niches to increase biodiversity.
- Monitoring outcomes. Tracking wildlife and their interactions with vegetation offers critical feedback for refining restoration strategies.
- Incorporation of biocrusts. Biocrusts (cyanobacteria, lichens, mosses) are vital for soil stabilization and water retention. Assessing biocrusts in restoration improves soil health and combats desertification, especially in Lebanon's varied ecosystems.

By embracing the interconnectedness of birds, mammals, and biocrusts, restoration projects will promote long-term ecosystem health, resilience, and biodiversity.

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Chapter 4

Policy Practices

The final chapter takes us to the broadest scale of building landscape resilience. We've seen that individual and collective action are valuable, but supporting frameworks are also needed if they are going to be effective in the longer term. Policies set rules, incentives, and funding arrangements that can make sustainable land management feasible and desirable.

Here are shown innovations based on financial mechanisms for valuing and measuring ecosystem services, carbon markets methodologies and landscape conservation funds. They also approach governance models that involve public institutions, private actors, and local communities in designing complex solutions. In this chapter is also discussed the role of agroforestry in the Agricultural and Climate Plans across five European countries: Cyprus, Greece, Italy, Portugal, Spain.

By aligning local action with facilitatory governance, financial systems, and global coordination, we can make conditions for resilient landscapes.

Declaration on Wildfire Management in Spain

Forum for debate and proposals for action for the management of large wildfires in Spain.



Community of experts discussing the challenges of wildfire management in Spain.
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Experts exploring wildfire-related challenges at the Madrid Forum.
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/// Context ///

Spain faces an escalating wildfire crisis exacerbated by climate change, requiring scientifically grounded strategies and societal involvement. The Declaration on Wildfire Management in Spain, developed through an inclusive process led by the Pau Costa Foundation, offers a comprehensive framework combining scientific knowledge, practical experience, and stakeholder participation. In March 2023, over 60 experts from diverse backgrounds contributed to this declaration in Madrid, focusing on short, medium, and long-term perspectives.

The declaration outlines seven thematic axes: enhancing forest resilience, planning resilient landscapes, fostering thriving rural communities, using controlled burns, educating society about fire, improving emergency management, and developing predictive models for extreme wildfires. It also includes three cross-cutting themes: collaborative governance, biodiversity conservation, and climate change adaptation. Collaborative governance promotes coordinated policies and shared responsibilities, biodiversity conservation aligns fire prevention efforts with habitat protection, and climate change adaptation focuses on adjusting fire services and societal practices to enhance resilience.

Declaration on Wildfire Management in Spain: debating and proposing actions to better manage large wildfire events.

Spain's wildfire management strategy, led by the Pau Costa Foundation, merges scientific knowledge, practical experience, and a participatory approach with over 60 experts for sustainable solutions.

A national plan disseminates the declaration through presentations at regional and local forums, supported by Pau Costa Foundation experts. Strategies to enhance media coverage and advocate for policy changes at regional and national levels are also in place. Internationally, the declaration is showcased at global environmental conferences for collaborative support and knowledge exchange.

Future initiatives proposed in the declaration focus on improving coordination among governmental and non-governmental entities, securing stable funding, investing in scientific research, and fostering community engagement. Key initiatives include establishing a centralised wildfire management body, developing a national wildfire risk assessment tool, and creating a national database for wildfire incidents. Pilot projects for community-based wildfire management are also being considered.

The Declaration on Wildfire Management in Spain outlines a framework for adaptive forest management, resilient landscapes, and community engagement to boost wildfire resilience and sustainability.

/// Solution for a Resilient Future ///

Spain faces an escalating challenge with wildfires, intensified by climate change and leading to unprecedented ecological and social consequences. Addressing this issue requires more than simple solutions; it demands comprehensive, scientifically backed strategies and widespread societal involvement.

The Declaration on Wildfire Management in Spain is a comprehensive document developed to address the increasing challenges posed by wildfires. It aims to provide a strategic framework for effective wildfire management by integrating scientific knowledge, practical experience, and a participatory approach involving various stakeholders.

The development of this declaration involved a rigorous and inclusive process. The Pau Costa Foundation promoted a forum for debate and proposals, held on March 2023 in Madrid, bringing together over 60 members of the wildfire community from diverse professional and social backgrounds. This forum aimed to gather comprehensive input on sustainable wildfire management strategies for Spain, taking into account short, medium, and long-term perspectives.

The declaration is structured around seven thematic axes, each addressing a specific aspect of wildfire management. These axes delineate the key challenges and objectives necessary to effectively manage large wildfires:

1. Management of forest ecosystems

Challenge: Create an alliance for adaptive management of forested areas to enhance their resilience to wildfires.

Objectives: Develop management tools, integrate planning at various scales, identify high-risk zones, and secure funding for sustainable forest management.

2. Territorial planning

Challenge: Plan diverse, resilient landscapes that facilitate safer wildfire management.

Objectives: Review and harmonise planning instruments, develop comprehensive landscape management strategies, and legislate for the inclusion of wildfire risk in land-use planning.

3. Living rural communities

Challenge: Foster thriving rural communities with a sustainable primary sector contributing to wildfire resilience.

Objectives: Create legal frameworks to support sustainable agriculture, promote local and ecological products, and develop participatory structures for communal land management.

4. Uses and ecology of fire

Challenge: Restore the ecological role of fire within ecosystems.

Objectives: Encourage the use of controlled burns and other traditional fire management techniques to reduce fuel loads and maintain ecosystem health.

5. Communication, education, and awareness-raising

Challenge: Equip society with the knowledge and tools to coexist with fire.

Objectives: Implement education programmes, increase public awareness, and promote community involvement in fire prevention and response.

6. Knowledge and needs regarding wildfire suppression

Challenge: Enhance emergency management capabilities.

Objectives: Develop advanced training for firefighting personnel, invest in new technologies, and improve coordination among emergency services.

7. Future scenarios in the medium and long term

Challenge: Prepare for future extreme wildfire events.

Objectives: Develop predictive models, plan for climate change impacts, and implement long-term adaptation strategies.

Addressing Wildfire Challenges in Spain: A Strategic Declaration,



Experts sharing insights and ideas from the breakout sessions with the rest of the participants at the Madrid Forum.
Author: Momentum Natura | © CC BY-NC-ND 4.0

Spain faces escalating wildfire challenges, intensified by climate change, leading to unprecedented ecological and social consequences. Comprehensive strategies and societal involvement are essential.



Presentation of the Declaration by the Pau Costa Foundation at Montserrat Natural Park (Catalonia, Spain).
Author: Pau Costa Foundation | © CC BY-NC-ND 4.0

The Declaration on Wildfire Management in Spain provides a strategic framework integrating scientific knowledge, practical experience, and stakeholder participation to address wildfire challenges.

In addition to the thematic axes, the declaration also incorporates three cross-cutting axes that influence all aspects of wildfire management:

1. Politics and Governance

Challenge: Ensure collaborative governance involving all stakeholders.

Objectives: Foster joint responsibility and develop coordinated policies across different governance levels.

2. Nature Conservation

Challenge: Align fire prevention with biodiversity conservation.

Objectives: Integrate fire management into conservation strategies and protect natural spaces from fire damage.

3. Climate Change

Challenge: Enhance resilience to climate change.

Objectives: Adapt fire services and societal practices to the changing climate, focusing on resilience and sustainability.

/// Always Moving Forward ///

The Declaration on Wildfire Management in Spain has developed a comprehensive dissemination plan. Nationally, it is being presented at regional and local forums throughout the Autonomous Communities of Spain. This is supported by experts who attended the initial forum, members of the Pau Costa Foundation, and other key regional actors in political, technical, and management spheres. Strategies are in place to enhance media coverage and advocate for policy changes at regional levels, such as within the various autonomous governments, and at the national level through the Senate and the Ministry of Ecological Transition. On the international stage, the Declaration is being showcased at global environmental conferences and other relevant platforms to highlight Spain's commitment to wildfire management and seek collaborative international support and knowledge exchange. Finally, the Pau Costa Foundation is promoting the Declaration on social media and has created a list of signatories, available on their website, for individuals and institutions to formally endorse it.

To address these challenges in the formulation and implementation of policies and management actions, the Declaration proposes future developments focused on enhancing coordination mechanisms among various

Future Steps for the Declaration on Wildfire Management in Spain.

governmental and non-governmental entities. Firstly, establishing a centralised wildfire management body could streamline efforts and improve response times. Securing stable and adequate funding through national and EU sources is crucial for sustaining efforts. Increasing investment in scientific research and ensuring its integration into policy and practice also needs to be prioritised. Additionally, fostering stronger community engagement through educational programs and participatory management practices will help ensure that local knowledge and needs are incorporated into wildfire management strategies.

In terms of governance, the current decentralised approach has revealed significant weaknesses. The lack of a unified strategy and clear lines of responsibility often results in delayed and ineffective responses. Improving this requires a more integrated governance framework that promotes collaboration and clarity of roles. Interdisciplinary approaches have also faced hurdles, particularly in aligning



Presentation of the Declaration by the Fénix Canarias Association in San José del Álamo (Gran Canaria, Spain).
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the diverse fields of ecology, forestry, urban planning, and emergency management. To improve, there must be a concerted effort to create interdisciplinary teams that can work seamlessly together, supported by regular training and cross-sector workshops.

Several new projects and ideas are in the pipeline in line with the main challenges identified in the Declaration. One such

The plan includes creating a central wildfire management body, securing stable funding, boosting scientific research, and fostering community engagement through education and participatory practices.

The Declaration on Wildfire Management in Spain features a dissemination plan with regional and international presentations, media strategies, and policy advocacy, supported by experts and key actors.

project is the development of a national wildfire risk assessment tool that incorporates real-time data and predictive analytics to better forecast and manage wildfire risks. Another initiative is the creation of a national database for wildfire incidents, which will serve as a valuable resource for research and policy formulation. Additionally, pilot projects focusing on community-based wildfire management are being considered, where local residents are trained and equipped to take an active role in preventing and responding to wildfires. These projects aim to build resilience at the community level and ensure that local knowledge is leveraged effectively.

In summary, while significant challenges remain in the formulation and implementation of wildfire management policies in Spain, the proactive steps outlined in the Declaration and the new initiatives planned offer a promising path forward. Through enhanced coordination, stable funding, scientific integration, and community engagement, Spain can develop a robust and effective wildfire management strategy that can serve as a model both nationally and internationally.

Further information

- List of signatories of the Declaration on the Management of Large Wildfires in Spain (link to join the Declaration). https://www.paucostafoundation.org/en/statement-on-the-management-of-large-forest-fires-in-spain-2/ (Accessed 17 August 2024)
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Authors / Partners: PCF – Pau Costa Foundation

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ResAlliance

Subsidizing fuel management in the Wildland-Urban Interface in the Barcelona province

The Barcelona Provincial Council provides municipalities with technical assistance and dedicated funds to implement the mandatory perimetral security strips around urbanized settings.



Works preparing the buffer zones around built areas.
Author: DIBA | © Educational use, non-commercial.



Felling of a tree by a forest worker.
Author: DIBA | © Educational use, non-commercial.

/// Context ///

Catalonia has a population of 7.5 million, with over 60% residing in the metropolis of Barcelona, which is a major tourist hub. Its Mediterranean climate, is coupled with a landscape dominated by continuous woody vegetation due to land abandonment and increasingly dry conditions from climate variations, is increasing the wildfire risk in the region. Additionally, settlement patterns, with many residential areas expanding into woodlands, further exacerbate this vulnerability. The wildland-urban interface (WUI) is the zone where human development meets forested landscapes. In the province of Barcelona, the WUI has significantly expanded in recent decades. WUI zones are of especial concern for wildfire managers and researchers because they are exposed to high wildfire risk, for several reasons. On the one hand, they have a high risk of ignition, due to large population densities. On the other, potential impacts of the wildfires are very high, due to high densities of human assets. As a response, the Barcelona Provincial Government has developed its Programme for the Prevention of Forest Fires in Residential Areas and Population Centres (PPU). This programme aims to reduce wildfire risk in areas where urban development is encroaching on (former) agricultural land, and many small agricultural plots are being abandoned, gradually transforming into unmanaged forests. There are two types of WUI: i) rural settlements interspersed with forests and ii) urban housing extending towards wooded areas. WUI areas present several challenges: human presence increases the likelihood of wildfires due to human-caused ignitions, and WUI fires pose a greater threat to lives and property. Naturally reducing biomass through fires in these areas is not feasible.

/// Solution for a Resilient Future ///

The Barcelona Provincial Council (DIBA) is a supramunicipal organization that encompasses 311 municipalities, covering 7,726 km² of land and serving 5.7 million inhabitants. DIBA offers various technical and economic support to town councils to foster progress and improve the well-being of citizens across the province. In 2004, DIBA initiated the Programme for the Prevention of Forest Fires in Residential Areas and Population Centres (PPU), in response to the 2003 Catalan law on perimeter security strips. The PPU provides subsidies to municipalities for the technical design and implementation of fire prevention measures.

The technical assistance provided by the PPU to town councils involves two main steps. Firstly, DIBA technicians create a delimitation map that identifies the urban areas, buildings, and facilities that must comply with legal security strip requirements. Second, they develop the Forest Fire Prevention Plan for Residential Areas and Population Centres, which includes the executive project detailing the interventions needed within the 25-meter security strips. The plan includes unbuilt plots, municipally-owned plots, and green zones within the urban area within the strip. The document outlines the layout of low-combustion perimetral strips

and lists the impacted properties. On a second step, DIBA funds the forestry works outlined in the executive project, covering both the execution of the forestry works and the management of the executive project.

Town councils must individually request support from the Technical Office of Municipal Prevention of Forest Fires and Agricultural Development (OTPMIDA) to access the PPU. Municipalities can request grants for up to five residential areas and population centres. A forced easement is imposed on lands within the 25-meter strip that do not belong to the municipality to permit necessary forestry works. This easement provides for compensation, including the value of the affected part of the servient estate and any damages caused by passage. If trees are to be felled, a forest exploitation communication is required to ensure compliance with fire prevention regulations. Authorization must be sought for activities posing wildfire risks if the works occur between 15 June and 15 September. DIBA provides open-access data on planned and executed security strips at gisportal.diba.cat/incendis.

The PPU is fully funded by DIBA, which subsidizes 80 to 100% of the costs for creating the strips and managing the project, depending on the municipality's population size (with smaller towns receiving higher subsidy rates). The minimum support is €2,000. Although the maintenance of the strips is not covered, OPTMIDA offers city councils a public price ordinance to raise funds for maintenance. The cost of creating a strip ranges from €3,000 to €6,000 per hectare, while maintenance costs range from €300 to €1,000 per hectare. Support is also available for preparing the legally required delimitation maps.



Strip around a built area in the Barcelona province.
Author: DIBA | © Educational use, non-commercial.



View of a strip in a downhill area.
Author: DIBA | © Educational use, non-commercial.

/// Always Moving Forward ///

Beyond the perimetral security strips, the PPU aims to prevent fires, reduce their consequences, and recover affected areas, while assisting town councils in achieving these objectives and fulfilling their legal obligations. The PPU collaborates with other sections within DIBA (E.g. Forest Restoration and Improvement, to transfer information on strips location, or the Fire Information and Monitoring Programme, about fire incidents during fieldwork). This helps to prioritize forestry work adjacent to those areas, such as buffer zones where forest is managed for fire prevention purposes.

OTPMIDA has partnered with the Research Centre for Ecological and Forest Applications (CREAF) to develop guidelines for perimetral security strips. They also work with the Rural Agents Corps of the Catalan government on raise awareness campaigns and communication materials, and with the Catalan Forest Firefighting Service to standardise the concepts of the delimitation maps across Catalonia. However, the economic support provided by DIBA may not be possible to replicate by other provincial governments with less resources. Therefore, it is important to carefully analyse which solution is feasible in each particular context.

Further information

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Authors: Carmen Rodríguez and Eduard Mauri | **Partners:** EFI – European Forest Institute

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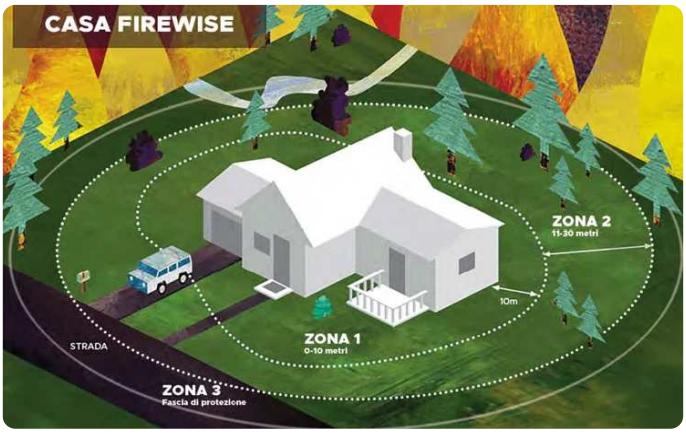
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Protecting neighbourhoods from forest fires at zero cost for residents: Firewise communities in Tuscany

An example of effective practices in Italy for protecting communities and homes from forest fires and preventing accidental ignition.



Firewise House Example.
Author: www.regione.toscana.it/firewise-comunità-antincendi-boschivi
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As the frequency and intensity of wildfires increase, people and communities living in the nature-urban interface are increasingly exposed to this risk.
Author: Scarlino Gestione P.A.F.R. | © Educational use, non-commercial.

/// Context ///

When a wildfire occurs, its impact extends beyond mere property damage. It disrupts the daily lives of entire families and communities, often leading to a long and arduous recovery process from such a traumatic event. As the frequency and intensity of wildfires increase, people and communities living in the nature-urban interface are increasingly exposed to this risk, which underscores the urgent need for effective risk management tools.

> **Firewise Communities: A collaborative approach to mitigate wildfire eisks and enhancing resilience in Tuscany.**

One successful instrument developed for this purpose is the Firewise Communities, originating in the USA by the National Fire Protection Association (NFPA); it is now a promising tool for fire prevention in Tuscany, Italy (see Kathleen Uyttewaal and Judith Kirschner in the “Further Information” section).

This concept is based on sharing risk principles between public institutions and private owners. The goal is twofold: to prevent forest fires from damaging homes and to prevent human activities in the wildland-urban interface (WUI) from exacerbating forest fire risks.

Through a protocol agreement, private citizens and local public entities organize and share fire prevention duties around properties. Private owners reduce the vegetation load around their structures by about 30 meters. At the same time, local authorities manage the protection strip in the adjacent wooded areas. The commitment is renewed annually to confirm the Firewise standards.

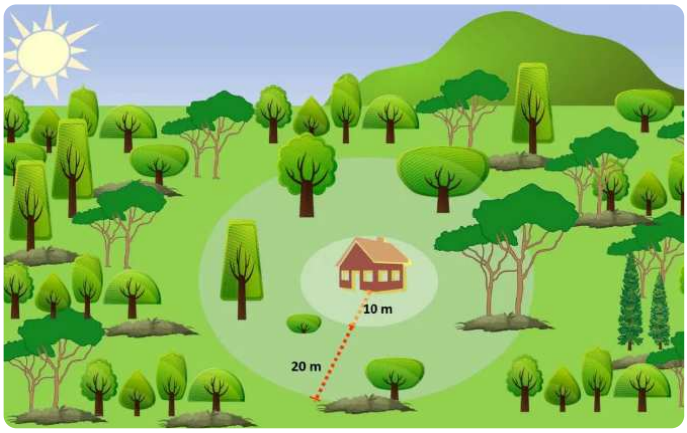
> **The Firewise Communities concept is based on risk-sharing principles between public institutions and private owners.**

Participation in Firewise Communities educates residents on defending their communities and forest heritage using best prevention practices and proper emergency response behaviours.

The benefits are substantial for all involved: private citizens secure their properties at minimal cost and effort, receiving social recognition and a certification from the Tuscany Region that increases their property’s economic value. Local authorities, meanwhile, benefit from a safer operational environment, reduced social costs in the event of a fire, and optimized resource management and utilization.

The implementation of Firewise Communities in Tuscany is a successful model of community engagement and risk management, highlighting how cooperation and shared responsibilities can significantly bolster defences against the threat of wildfires, ensuring both individual and collective resilience.

> **The increase in the frequency and intensity of fires underscores the urgent need for effective risk management tools.**



The agreement divides the area surrounding the community into three zones.
Author: D.R.E.Am Italia | © Educational use, non-commercial.



Villana before the works on defence space.
Author: www.regione.toscana.it | © Educational use, non-commercial.

/// Solution for a Resilient Future ///

Developing a Firewise Community is a collaborative process involving multiple stakeholders. In Tuscany, these include public entities like Municipalities, competent bodies related to fire prevention, and private actors such as local citizens and volunteer associations.

- The process starts with public institutions selecting an appropriate site for those particularly exposed to wildfire risk. Once the area is selected, the competent body determines the feasibility of the community establishment. Accordingly, the Municipality identifies property owners who should participate in the community development, informs them about the Firewise principles and project details, and involves them in the project approval. Until now, once the landowners have been reached, there is a very high percentage of participation: local authorities estimated participation among 80-90% of the landowners identified.
- After all the necessary actors are engaged, the competent body can develop a detailed action plan, specifying which actions each subject must implement to reach the Firewise standards. The owner's involvement in this phase is essential. They have to develop their houses' defense project with the competent body and then sign the necessary document to grant access to their land to construct the external firebreak. The finalized and signed executive plan is then proposed to the Municipality, which approves it after securing the necessary authorizations.
- The process can then pass to the operational phase. The competent body and property owners execute the duties they are entitled to, respectively, creating the fire protection strip and the defensive space close to the houses.

Participation in Firewise Communities educates residents to defend their community and forest heritage using best prevention practices and proper emergency response behaviors.

Establishing Firewise Communities: The case of Villana, Tuscany, Italy.

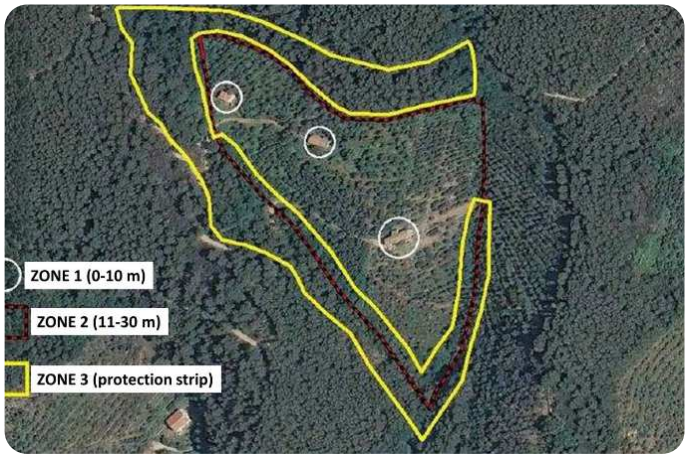
- The competent body is then responsible for inspecting and certifying the proper execution of these works. Upon successful verification, the Municipality endorses the Firewise community's establishment and forwards it to the Regional Administration for official certification.
- The final step involves the Tuscany Region, which grants certification to the newly established Firewise community.

One example of this process is the establishment of the Villana Firewise Community, part of the Municipality of Calci in Tuscany. Situated 350 meters above sea level and surrounded by forest, Villana represents a wildland-urban interface highly vulnerable to fire risk.

The community comprises three houses surrounded by olive crops, which serve as a natural buffer between the residences and a large, dense forest. This forest is predominantly covered by maritime pine, generally accompanied by a thick shrub layer of heather and other species typical of the Mediterranean area. Due to its dense nature and flammability, this vegetation composition is classified in the Wildlife Prevention Plan of the area as the fuel type with the highest fire risk.

This prevention plan also provides a detailed risk assessment to evaluate the wildfire threat to Villana based on various hazard and vulnerability factors such as type and vegetation density, topographic features, and exposure level. The risk index, which ranges from 1 to 4, categorizes Villana as having the highest risk level of 4.

Homeowner involvement is essential: they develop their home defense project with the appropriate agency to build the firebreak.



Map of the planned works in the Firewise Communities of Villana (Tuscany, Italy).
Author: www.regione.toscana.it/firewise-comunità-antincendi-boschivi
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The Municipality of Calci engaged with the local families to present the Firewise Community project. After consultations, the outline project was approved by both the Municipality and the property owners, leading to the drafting of the executive project and the obtaining of the necessary approvals to proceed.

The agreement divides the area surrounding the community into three zones and indicates the responsibilities of the parts involved:

- Zone 1: it comprises the 10 meters around the houses. In this area, homeowners must cut the grass frequently, prevent the accumulation of dead plant material, and manage the spacing of shrubs and trees.
- Zone 2: it extends from 11 to 30 meters from the houses and mainly consists of olive crops. The owners must prune their trees and cut the grass to maintain the fuel's vertical and horizontal discontinuity.
- Zone 3: beyond 30 meters, this zone is managed by the Municipality and designated as a critical fuel break area. The Municipality conducts extensive vegetation management to eliminate fuel continuity, promote the growth of broadleaf trees, and maintain open spaces as necessary.

The agreement also specified that these operations had to be completed within a year. Once all activities were accomplished, the Municipality verified the work and requested the Tuscany Region's certification, which was granted. Now certified, the community must annually repeat the process to maintain its Firewise certification.

Homeowners avoid the accumulation of dead plant material around homes by maintaining vertical and horizontal fuel discontinuity, public agency promotes broadleaf growth, and maintain open spaces.

/// Always Moving Forward ///

The Firewise community initiative was launched in Tuscany by establishing four pioneering communities in the provinces of Pisa and Grosseto, specifically in the municipalities of Calci, Vicopisano, Castiglione della Pescaia, and Scarlino. This initiative has now become a pivotal component of Tuscany's forest fire management and prevention strategy, featured in the Regional Fire Prevention Plan for 2023-2025.

These initial trials have been successful, with citizens responding enthusiastically by actively collaborating with institutions. This cooperation has enabled the punctual fulfilment of the activities stipulated in the agreements, resulting in the acquisition of the Firewise certification for all the communities involved.

The numerous benefits to all parties involved make this initiative highly attractive. Private citizens benefit by securing their properties at minimal cost and effort, with all planning and bureaucratic responsibilities delegated to public authorities. Economically, property owners gain as the costs associated with maintaining the exterior protection strips, even though the land is privately owned, are covered by public funds. Furthermore, they enhance their social prestige and contribute to community resilience.

Public institutions also see substantial benefits. Establishing fire-safe communities significantly reduces the social and financial costs of fire incidents by ensuring people's safety and creating safer operational environments. Moreover, these efforts lead to optimized resource management, as resources are allocated more effectively.

Another crucial aspect that should be considered is the social element of the Firewise project.

The relationships that residents forge among themselves support building a resilient community to catastrophic events. The Firewise community initiative offers an additional platform for citizens and institutions to collaborate towards a common goal.
This collaboration fosters strong bonds and a trustful relationship that benefits the entire community, particularly in case of emergency.

Improving and expanding Firewise Community initiatives in Tuscany.

The Firewise communities initiative was launched in Tuscany with the establishment of four pioneer communities in the provinces of Pisa and Grosseto.

Despite these successes, there is still room for improvement. For instance, many communities need help with the annual Firewise certification renewal process. Local governments are working to streamline and expedite this bureaucratic process to facilitate easier renewals.

Efforts are also being made to enhance the economic value of properties involved in the initiatives. Negotiations are ongoing with insurance companies to lower insurance premiums for homes with Firewise certification, which could further incentivize participation and boost property values.

Moreover, plans are underway to expand the functional role of Firewise districts. Currently serving as critical buffers that prevent wildfires from spreading between forests and residential areas, the ambition is to transform these communities into safe zones for local populations during fire emergencies.



Firewise Community logo of Villana.
Author: www.regione.toscana.it/firewise-comunità-antincendi-boschivi
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In conclusion, the Firewise community initiative has emerged as an auspicious tool for managing fire risks in Tuscany. Encouraged by the positive outcomes, efforts are now being made to establish Firewise communities in three additional municipalities, Massarosa, Tirli, and Capoliveri. This expansion underscores the initiative's effectiveness and the broad recognition of its value in enhancing community safety and resilience.

Negotiations are underway with insurance companies to reduce insurance premiums for Firewise-certified homes, which could further incentivize participation and increase property values.

Currently, Firewise communities serve as critical buffers that prevent wildfires from spreading between forests and residential areas.

Further information

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Acknowledgment / Contribution

Thanks to Lucrezia Proietti for her contribution in synthesising and checking the document.

Authors: D.R.E.Am. Italia (Sbaragli, Galfré, Miozzo, Martini) | **Partners:** D.R.E.AM. Italia

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Type of Solution: Management Sector: Forestry

Good practice(s): Management alternatives, Protection against biotic and abiotic hazards

Prescribed burning on the island of Chios, Greece: results from a two-year pilot project

A pilot project on prescribed burning in Greece to introduce the use of fire as a tool for forest fuel management and to improve social and ecological resilience of natural ecosystems.



Treating and extending a shaded fuel break with prescribed burning.
Author: Andrea Bonetti | © Educational use, non-commercial.



Conducting a prescribed burn in a fuel break.
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/// Context ///

Researchers and practitioners from the Institute of Mediterranean Forest Ecosystems of ELGO DIMITRA, WWF Greece, the Forestry Directorate of Chios Island and the Voluntary Action Team OMIKRON have implemented a two-year pilot project on prescribed burning on the island of Chios, Greece, with the aim of introducing this method as a tool for forest fuel management.

Prescribed burning is an effective management tool that can have beneficial outcomes such as reducing fire risk and promoting ecosystem health. Monitoring the effects of its use is essential to improve standards and procedures for its application and to minimise potential negative effects on the natural environment.

Fire behaviour data, obtained from experimental prescribed burning in Mediterranean-type forest ecosystems on the island of Chios, were compared with fire effects on different variables characterizing soil properties, the effects on trees, and in plant biodiversity.

The results showed that prescribed burning did not cause significant changes in vegetation physiological functions and soil properties, while there is evidence that it had a positive effect on plant diversity.
The project's experimental trials also provided an excellent training tool for participants (firefighters, land managers and researchers).

/// Solution for a Resilient Future ///

The first efforts to introduce and use prescribed burning in Greece began in the 1970s, when members of the Greek forestry scientific community and the Hellenic Forest Service applied prescribed burning experimentally, analysed data and drew some preliminary conclusions. They took some steps to document the use of fire and study its effects before introducing prescribed burning as a tool to prevent forest fires. Unfortunately, without consistent funding, legal support, logistics, ongoing scientific guidance and clear objectives, these sporadic attempts failed to connect with the forest and fire management community and the effort was soon abandoned. Almost half a century later, fire is still not used for fuel management and fire prevention, and there is no institutional framework for the implementation of prescribed burning.

Inspired by the potential of prescribed burning demonstrated in other Mediterranean countries, and guided by fire science and best practices for forest fire prevention, a core team of researchers and practitioners from the Institute of Mediterranean Forest Ecosystems of ELGO "DIMITRA", WWF Greece, the Forestry Directorate of Chios Island and the Voluntary Action Team "OMIKRON" started a pilot project to implement prescribed burning on the island of Chios in 2021. The Fire Service of Chios Island and the Municipality of Chios supported the pilot project by providing water trucks and personnel during the burns. The General Directorate of Forests and Forest Environment of the Ministry of Environment and Energy provided all the necessary permits for the implementation of the pilot application of prescribed burning in Chios.

Throughout the project, prescribed burning was experimentally applied to surface fuels in pine (Pinus brutia) stands, tall evergreen sclerophyllous shrubs, low spiny Mediterranean shrubs (Phrygana) and young pine regeneration, with the aim of maintaining fire and fuel breaks by reducing fuel loads and controlling regeneration. Through these efforts, prescribed burning was successfully demonstrated. The results provided strong evidence that prescribed burning can be a very effective fuel management tool for many forest ecosystems in Greece. There is now a good basis for applying the method in the country, although further research (e.g. under different conditions and in additional ecosystems) is needed before it can be fully adopted and included in the toolbox of forest fire managers. Standards and procedures for the application of prescribed burning in Greece are being developed following the successful paradigm on Chios. The official adoption of this method by the Hellenic Forest Service will strengthen its role and effectiveness in fuel management and improve cooperation between state agencies and local stakeholders. In addition, the use of prescribed burning under the guidance of the Forest Service can become an excellent training tool for professional and volunteer firefighters.



Prescribed fire treatment of a shaded fuel break covered by young Pinus brutia trees.
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Prescribed fire treatment of a shaded fuel break without killing its Pinus brutia trees and Pistacia terebinthus shrubs.
Author: Miltiadis Athanasiou | © Educational use, non-commercial.

/// Always Moving Forward ///

Prescribed burning is used in some Mediterranean countries, but not in others, such as Greece. The potential benefits are known, but there are also pitfalls, so there is a general reluctance to adopt this method. This reluctance is often due to lack of familiarity with its use. In addition, there are often legitimate questions about its effects, which can vary from one ecosystem to another. The pilot project on Chios aims to overcome both of these drawbacks. On the one hand, it demonstrates the feasibility and parameters for the effective use of prescribed burning, and on the other, it evaluates the ecological effects through carefully planned and detailed monitoring, trying to identify potential problems.

The knowledge gained from this work can help to institutionalise prescribed burning in Greece, following specific application standards that are currently being developed. These standards will include carefully planned reporting practices that will help to build knowledge, evaluate results, improve effectiveness and efficiency, and identify any undesirable consequences early on. It is also hoped that this work will provide an example for other countries around the Mediterranean to follow in adopting the method in their fire management practices.

Further information

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Partners: ELGO – DIMITRA – The Hellenic Agricultural Organization

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MediterRe3: Building Fire-Smart Landscapes in the Mediterranean region

Restoring the resilience of Mediterranean landscapes to wildfires.



Rural Mosaic Landscape – Samaria National Park – Crete, Greece.
Author: Ilektra Remoundou, CIHEAM-MAICh | © Educational use, non-commercial.



Rural Mosaic Landscape – Samaria National Park – Crete, Greece.
Author: Alessio Martinoli, Istituto Oikos | © Educational use, non-commercial.

/// Context ///

The Mediterranean basin has undergone a notable trend of rural areas being abandoned, accompanied by the cessation of traditional farming activities. This shift has resulted in stand-level fuel accumulation and increased landscape fuel connectivity. The combined impact of fuel load accumulation in landscapes and fire-prone weather conditions, exacerbated by climate change, is creating high favorable conditions for extremely intense wildfire events. These extreme wildfires, also known as sixth generations fires, are leading to a substantial degradation of Mediterranean forests and their associated natural, cultural, and economic values. Existing fire management policies have primarily focused on fostering fire suppression capacity rather than prioritizing prevention and land management practices. The prevalence of the fire suppression model, marked by significant investments in operational crews, vehicles and aerial means, contributes to reducing damages in the short-term, yet it fails in addressing the underlaying causes of the problem, generally leading to poor long-term results. Given the projected trajectory of climate change, a shift in emphasis from suppressing fire to major preventive landscape planning is needed. Currently in Europe, there is general agreement for a wildfire risk management change towards cause-oriented policies, with a particular focus on preventive landscape planning and fire-smart management practices.

/// Solution for a Resilient Future ///

Despite the countless efforts and resources devoted to fire management and response capacity, the problem of wildfires persists. Most of the wildfire management public policies and funding in the Euro-Mediterranean countries still focus on sophisticated extinguishing equipment for fire suppression, undervaluing the need of major preventive landscape planning and the prioritization of locally adapted, cross-sectoral and innovative fire-smart land uses and management measures.

Given the projected trajectory of climate change, a shift in emphasis from suppressing fire to major preventive landscape planning is needed. This shift (proactive vs reactive approach) will help maintaining the landscape fuel load within acceptable level, reducing the magnitude of potential fires and facilitating effective responses. Central to this approach, is the concept of a Fire-Smart Landscape (FSL), representing a territory where management efforts are dedicated to reducing fire risk while simultaneously fostering ecological and socioeconomic benefits, and in which land use activities (e.g., agro-forestry, nature conservation) concur with planned fuel treatments in



FLR principles and their correspondence with FSL planning.
Author: Regato et al., 2023
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regulating the spatial distribution of fire and its impacts, improving fire suppression effectiveness while obtaining benefits for ecosystem services and local economic development. This integrated and proactive approach not only addresses immediate fire risks but also promotes sustainable practices harmonized with the natural environment. It ensures a reduction in fuel load and contributes to decreasing the vulnerability of local communities exposed to wildfires, subsequently minimizing losses and damages.

Planning for Fire-smart landscapes (FSL) should be based on the conceptual framework and set of guiding principles known as Forest Landscape Restoration (FLR). FLR is defined as "a large-scale and long-term process leading to the recovery of the ecological functionality and the improvement of human livelihoods in degraded landscapes, in a way that increases the ecological and socio-economic resilience against environmental risks – such as large wildfires – and the ecosystem services upon which we all depend". Guided by six principles, FLR emphasizes landscape-scale implementation over single-site efforts, incorporating both socio-economic and ecological dimensions. It is intended to propose a series of solutions that can incorporate diverse techniques and approaches. Additionally, FLR actively engages a diverse range of stakeholders in planning and decision-making processes, recognizing the necessity of negotiation and trade-offs to align with varying interests and priorities. Enhancing landscape resilience to wildfires necessitates an understanding of the complex interactions within the landscape. In this context, FLR principles act as a valuable tool for identifying correspondent FSL principles which serve as a guide for effective planning of fire-smart management practices that would help reduce the risk of fire ignition and spread.

Focus on the entire landscape	FLR takes place within and across entire landscapes, not individual sites, representing mosaics of interacting land uses and management practices under various tenure and governance systems. It is at this scale that ecological, social, and economic priorities can be balanced.	FLR interventions aim to restore multiple ecological, social, and economic functions across a landscape and generate a range of ecosystem goods and services that benefit multiple stakeholder groups.	**Restore multiple functions for multiple benefits**
Tailor to the local context using a variety of approaches	FLR uses a variety of approaches that are adapted to the local social, cultural, economic, and ecological values, needs, and landscape history. It draws on the latest science and best practices, as well as traditional and indigenous knowledge, and applies that information in the context of local capacities and existing or new governance structures.	FLR actively engages stakeholders at different scales, including vulnerable groups, in planning and decision-making regarding land use, restoration goals and strategies, implementation methods, benefit-sharing, monitoring, and review processes.	**Engage all stakeholders and support participatory governance**
Maintain and enhance natural ecosystems within landscapes	FLR does not lead to the conversion or destruction of natural forests or other ecosystems. It enhances the conservation, recovery, and sustainable management of forests and other ecosystems.	FLR seeks to enhance the resilience of the landscape and its stakeholders over the medium and long-term. Restoration approaches should enhance species and genetic diversity and be adjusted over time to reflect changes in climate and other environmental conditions, knowledge, capacities, stakeholder needs, and societal values.	**Manage adaptively for long-term landscape**

Forest Landscape Restoration principles.
Author: CIHEAM - MAICH | © Educational use, non-commercial.

/// Always Moving Forward ///

The concept of fire resilience has become increasingly relevant as society looks to understand and respond to recent wildfire events. In particular, the idea of a fire resilient landscape' is one which has been utilized to explore how society can coexist with wildfires. However, the concept of fire resilient landscapes has often been approached in silos, either from an environmental or social perspective; no integrated definition exists. Based on a synthesis of literature and a survey of scientists and practitioners, fire resilient landscape is defined as "a socio-ecological system that accepts the presence of fire, whilst preventing significant losses through landscape management, community engagement and effective recovery". This common definition could help guide policy surrounding fire resilient landscapes, and exemplify how such landscapes could be initiated in practice. the applicability of the proposed definition in both Mediterranean and temperate Europe should be further explored .

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Efficient wildfire prevention in Mediterranean environment: a study case

How can we merge fuel management, public & private properties and forest fire fighter's needs? Real case in Tuscany (Italy).



Example of prevention-silvicultural work in WUI area foreseen in the SPP.
Author: D.R.E.Am. Italia | © Educational use, non-commercial.



The forest fires Specific Prevention Plans (SPP) developed until today.
Author: Tuscany Region | © Educational use, non-commercial.

/// Context ///

The change in fuel models, the higher fuel continuity available in Mediterranean forests, the increased number of urban-forest interface areas and the ongoing climate change increased the risk of large forest fires, even simultaneous ones. Having faced particularly challenging seasons in recent years, with forest fires that have threatened public safety, the Tuscan Forest Fires Organization has become aware that active fighting alone and an exclusively emergency approach cannot be the solution to the forest fires problem, now as in the future. The Tuscany Region Administration has, therefore, modified its Forestry Law (R.L. 39/00), inserting a new instrument to guarantee effective interventions to prevent large wildfires, and has allocated 400,000 euros for the elaboration of the first twenty forest fires Specific Prevention Plans (SPP) that involve some of the regional areas most at risk, acting in public as in private properties. The final objective to approach the wildfires issue in this way is not to "delete" wildfires in Tuscany Region, but to reduce the risk to have the big ones and the most dangerous ones. This is reached by managing the fuel (vegetation) in strategic areas and in Wildland-Urban Interface (WUI) areas: for example, the final amount of forest area that is planned to manage usually is between the 5-10% of the total forest covered area. This results in not planning to manage all the forest area, but only the stratgic areas which can be critical and trigger points for the most dangerous and extended wildfires.

/// Solution for a Resilient Future ///

Over the last decade, the frequency and extent of forest fires in Tuscany have been influenced by a marked variability in the weather conditions that favour the ignition and spread of fires. The climate change that is taking place favours extreme phenomena – such as long dry periods, frequent heat waves, days with strong winds – which, even in years that are not very demanding for the regional fire-fighting organisation, can lead to short periods characterised by extremely favourable conditions for the development of large fires. The profound socio-economic changes that have taken place in recent decades have favoured the urbanisation of rural areas and the transformation of the landscape, with the proliferation of urban-wildland interfaces that are often unmanaged or poorly managed in terms of forest fuels, with the result that the continuity of vegetation cover has exponentially increased the risk of fire to infrastructure and the population. It is clear that in these new scenarios, active fire-fighting alone, however professional and effective, is no longer sufficient, and the change in strategy requires that priority be given to preventive action, identifying the areas in the territory most exposed to the risk of forest fires and the strategic management points where targeted interventions can be carried out in a 10-year programme of silvicultural works in areas of high fire risk, acting in public as in private properties. One is the area of the coastal pinewoods of Grosseto and Castiglione della Pescaia, characterized also by a very

high diffusion of touristic facilities, but other areas have been already included in the group of the high fire risk area for which a plan has been designed and which works are implementing.

The objectives are:

- Avoid large wildfires, creating strategical areas of horizontal and vertical discontinuity in the vegetation
- Carry out interventions on the territory in Strategic Management Points (SMP)
- Plan interventions for the next 10 years highlighting priorities
- Limit the risk of damage to people and infrastructures with forestry treatments in forest-urban interface areas and with self-protection for inhabitants
- Sharing the aims of the SPP with citizens and stakeholders, also through a specific communication plan
- Adaptation of the municipal Civil Protection Plan to the requirements of the SPP

The interventions are carried activating resources under the Rural Development Programme, other interventions are carried out with funds from the Region of Tuscany and the Interreg V Programme – MED-Forest project.

This involves the clearing of the undergrowth (Mediterranean sclerophyllous and broadleaf trees) during which scattered groups or single broadleaf trees are released over about 10% of the surface area, while maintaining an adequate distance from the crowns of the pine trees above. On the upper story of pines, felling is carried out of plants that are dead and in poor vegetative condition. Also forestry roads are managed in order to be effective in case of use during wildfires by fire service, and water points are established or recovered to make them useful and available for ground and aerial teams.



Example of prevention-silvicultural work in WUI area foreseen in the SPP.
Author: D.R.E.Am. Italia | © Educational use, non-commercial.



Example of silvicultural work in WUI area foreseen in the SPP.
Author: D.R.E.Am. Italia | © Educational use, non-commercial.

/// Always Moving Forward ///

The methodology used to identify Strategic Management Points and the procedure to apply that (interventions in both public and private properties possible thanks to the amendment of the Regional Forestry Law) has already been replicated on a landscape scale in all high fire risk areas (see the link: https://www.regione.toscana.it/piani-specifici-di-prevenzione) in the regional territory. Through field surveys, study of local historical fires, of local meteorology, of the presence of human settlements, of the change in population density during the summer season, and the historical fires behavior, the SPP establishes the preventive silviculture interventions to be implemented in the SMPs. Using the Flammap propagation model, simulations are also carried out to define potential fire behavior. The SPP also includes specific indications for the adaptation of Civil Protection Plans by the municipalities concerned. It is clear that failure to carry out the planned actions would expose these areas to the persistence of such high fire risk conditions as to make them indefensible with active fighting alone.

Further information

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Authors: D.R.E.Am. Italia (Sbaragli, Galfré, Miozzo, Martini) | **Partners:** D.R.E.AM. Italia

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Type of solution: Governance Sector: Agroforestry
Good practice(s): Soil management, Management alternatives, Ecosystems services, Financing

Agroforestry in the Portuguese Agricultural and Climate Plans

The Portuguese CAP Strategic Plan (2023-2028) is unique compared to other Member states, since it claims that that agroforestry is only possible in permanent pasture.



Figure 1. Black merino sheep under scattered holm oak in Southern Portugal.
Author: João Palma | © CC-BY



Figure 2. The Competence Centre for Cork Oak has an app to help find the right spot for cork-oak, based on climate and soil (Paulo et al. 2015).
Author: Pexels | © CC-BY

/// Context ///

The Portuguese CAP Strategic Plan and is unique in not recognising silvoarable systems: "agroforestry systems in Portugal are based on natural regeneration processes, which prevent the alignment of trees, and promote undercover systems with meadows and permanent pastures rather than annual crops. In this sense, (…) due to the difficulty of combining a density of trees with the necessary installation and harvesting of arable crops, it is considered that arable land cannot form agroforestry systems".

Cork oak, olive trees, stone pine and chestnut and most fruit and nut-trees which are commercially exploited for cork or fruits are considered as "permanent crops", and only non-commercial production with these species is considered as "agroforestry", with minimum densities set at 40-60 trees/ha, depending on species.

Permanent pastures under Quercus are 100% eligible for basic payments (BISS), but the eligibility of other species depends on crown cover, with >75% being ineligible. Unlike neighbouring Spain, permanent pastures containing edible shrubs and no grass cannot be declared as eligible for BISS. Environmentally important landscape features can be declared in the LPIS by farmers and are 100% eligible for BISS (Figure 4). Two ecoschemes may apply to agroforestry ("permanent pasture management" and "practices promoting biodiversity") and grants exist both for the establishment of agroforestry (Article 73) and for annual maintenance (Article 70). See Policy Briefing #42.

/// Solution for a Resilient Future ///

BETTER MONITORING. Data from the Portuguese LPIS system (ISIP) is not made available in the EU Inspire Portal, but is in the DGAGRI Member States Geoportal, and is available in a public portal. Areas of forest are not included, unless they receive CAP payments. CAP Result Indicator 17 (tree planting) is given only as total (212,783 hectares) for the full CAP period, and not broken down into the sub-categories afforestation (17.1), reforestation (17.2), agroforestry (17.3) and woody landscape features (17.4). Output Indicator 16, shows annual maintenance payments made for tree-planting, but again does not split the planned figure (201,074 hectares) between afforestation and agroforestry. Impact Indicator 21 should give the area of Landscape Features, but is not yet available for Portugal.

WIDER IMPLEMENTATION. Portugal has around 1.2 Mha of agroforestry (den Herder et al. 2015), and has the lowest percentage area of "tree deserts" on cropland/grassland in the EU (Figure 3). This reflects its mosaic landscapes and high forest cover, but there are still zones with low tree cover where more agroforestry is needed. Portugal excludes silvoarable systems from its definition of agroforestry, and this is unique amongst Member States. The Portuguese CAP Strategic Plan includes potentially good investment and agri-environment support to agroforestry, but the uptake of these schemes is not yet clear, and available statistics do not separate afforestation from agroforestry targets.

SHARING KNOWLEDGE. The strengths of Portuguese agroforestry policy are summarised in EURAF Policy Briefing #42 as: a) one of the largest areas and longest-established areas of agroforestry in Europe (Reis et al. 2019; Belo et al. 2019); b) extensive literature on agroforestry in permanent crops like vines, olives and fruit trees; c) recognition of the importance of agroforestry for climate-mitigation and adaptation; d) recognised as a crucial part of Portuguese forestry expertise in universities and professional associations (e.g. IUAF); e) the subject of recent conferences (e.g.). Weaknesses can be summarised as: a) lack of data on uptake of agroforestry measures; b) lack of data on agroforestry targets; c) confusion the rules for landscape features and direct payments eligibility of parcels with trees; d) uncertainty over which Pillar II measures can support agroforestry; e) apparent exclusion of silvoarable systems from support.

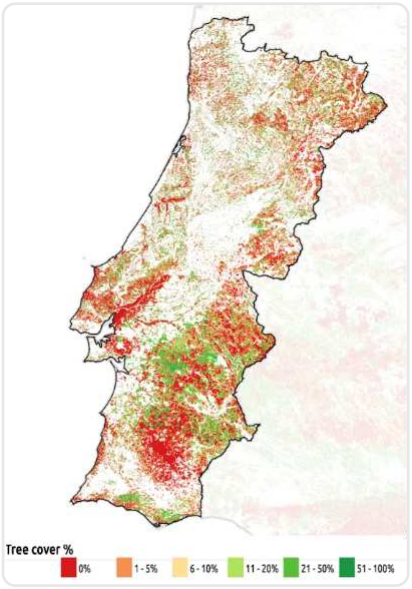


Figure 3. Tree cover density in Portugal on grassland/cropland, using data from Copernicus and Corine from 2018 (100m pixels). Intense red colours indicate that the area has no tree cover.
Author: DigitAF Project | © CC-BY

PORTUGAL	LF - Weight	LF - Areas	LF - Protected
1 Buffer Strips		y	
2 Cairns			
3 Cultural Features			y
4 Ditches	2	y	y
5 Field margins and patches			
6 Woody-landscape-features			
6.1 Hedgerows			
6.2 Trees in Line	2	y	y
6.3 Groves/copses	1,5	y	y
6.4 Individual trees	1,5	y	y
6.5 Scrub or forest margins	2	y	
7 Land lying Fallow	0.3	y	
7.1 Fallow land with melliferous plants	1.5		
8 Others			
9 Small Ponds	1,5	y	y
10 Small Wetlands			
11 Stonewalls	1	y	y
12 Streams			
13 Terraces			

Figure 4: Landscape features in the Portuguese CAP Strategic Plan: showing weighting for contribution to GAEC-8 targets, features selected and whether protected.
Author: EURAF | © CC-BY

/// Always Moving Forward ///

EMISSION TARGETS. The EU LULUCF Regulation (2023/839) gives Portugal a net emission target of -1.358 MtCO2e/yr for 2030, compared with -390 MtCO2 in 2016-18. The Portuguese draft National Integrated Energy and Climate Plan (NECP 2021-2030) thinks this is achievable, with -9.567 MtCO2e/yr estimated in 2030. This is partially due to agroforestry, since the Forestry Accounting Plan (FAP) (2021-25) includes as much as 2.3 Mha of forest land in agricultural use. The FAP suggests an afforestation target 8,000 ha/yr by 2030, but the CAP Strategic Plan goes higher, with 212,287 hectares planned for 2023-29, as the sum of afforestation, restoration and agroforestry.

CARBON CERTIFICATION AND AGROFORESTRY. The 2010 National Forest Inventory (NFI), estimates that agroforests cover 716,000 and 413,000 hectares respectively for cork oak and holm oak respectively. This can account for 30% of the total carbon (C) present in Portuguese forests: with cork oak storing 64 million and holm oak storing 20 million Mg CO2eq (IUAF). Agroforestry-carbon-farming certification will become very important in Portugal, helped by the Delegated Act being developed by the Commission for "Monitoring, Reporting and Verification". The ResAlliance project will contribute to the section of these rules on "agricultural soils and agroforestry".

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Agroforestry in the Cypriot Agroforestry and Climate Plans

How is agroforestry defined in Cyprus? Is it mentioned in national energy and climate planning? Will the coming opportunity for carbon-farming make it more attractive?



Figure 1. Cedar of Lebanon (Cedrus libani) is native to the Troodos Mountains in western Cyprus, although it is considered vulnerable to climate change.
Author: Cyprus Mail | © CC-BY



Figure 2. Carob fruits can be a substitute for chocolate and eaten raw or ground up to make sweet syrups, spreads, toffees, drinks and as a sweetener.
Author: Cyprus Mail | © CC-BY

/// Context ///

The Cypriot CAP Strategic Plan (2023) indicates that "agroforestry systems can be planted or naturally occurring systems on agricultural land, where forest trees and agriculture share the same plot. They can occur in cropland, permanent crops or permanent pasture and the forest and agricultural species can grow over the whole area of the plot or on boundaries, such as windbreaks with cypress trees. On permanent pasture, forest herbaceous plants and animals share the same plot. These occur mainly in the semi-mountainous zone and are natural ecosystems of Mediterranean shrublands and eastern heathlands". No tree-density limit is mentioned.

Agroforestry measures in the previous CAPs (Submeasure 8.2 during 2015-2022 and Measure 222 in 2007-2014) were not implemented in Cyprus. Similarly, in the present CAP (2023-2029) none of the specific agroforestry eco-scheme, investment or agri-environment climate payment options have been implemented. There may however be scope for flexibility in the ecoscheme "regimes for climate and environment", the investment measure "afforestation and woodland creation" or the agri-environment payment "conservation of woody area". Only 50 hectares of afforestation is planned, and this does not reflect the government´s climate target of planting 300,000 trees by 2030.

/// Solution for a Resilient Future ///

BETTER MONITORING. The Cypriot Land Parcel Information System (CLIS) data is not made available in the EU Inspire Portal but it is in the Member States Geoportal. The LPIS allows identification of individual parcel boundaries, of land uses and (sometimes) of landscape features like lines of trees or terraces. The Cypriot CAP Strategic Plan Result Indicator 17 has only identified 50 hectares of trees to be planted in the 2023-29 period, but has not indicated how this total will be split between afforestation (17.1), reforestation (17.2), agroforestry (17.3) or woody landscape features (17.4). It gives only a single figure (50 hectares), with no breakdown. Cyprus has not attributed any expenditure to Output Indicator 16, which shows annual payments made for tree-planting.

WIDER IMPLEMENTATION. Although Cyprus has around 47.5 Mha of agroforestry (den Herder et al. 2015), it also has extensive "tree deserts" (Figure 4). These are areas of cropland and grassland with extremely low tree-crown-cover, and tend to be in areas with mineral-soils and high environmental pressures. Establishment of agroforestry in districts with greatest "tree deserts" should be given priority. The Cypriot CAP Strategic Plan lists many ecoschemes, and measures for investment and agri-environment, but, none of the schemes specifically mention agroforestry.

KNOWLEDGE SHARING. The strengths of agroforestry in Cyprus are summarised in EURAF Policy Briefing #49. Published literature on agroforestry in the country is limited, but it is estimated to have: a) the largest proportion of utilised agricultural area covered by agroforestry; b) extensive experience of agroforestry in permanent crops like vines, olives and fruit trees; c) increasing recognition of the importance of agroforestry and tree planting for climate-mitigation and adaptation including a pledge to plant 100,000 per year.

The weaknesses are a) no agroforestry eco-scheme, investment or maintenance measures exist for agroforestry in the current CAP; b) agricultural payments are made only on a very small area of grassland, and new grassland definitions have not yet been included in the LPIS system (CLIS); c) incomplete recording of woody landscape features in the Cypriot LPIS system; d) uncertainty over eligibility for basic payments of parcels with trees.

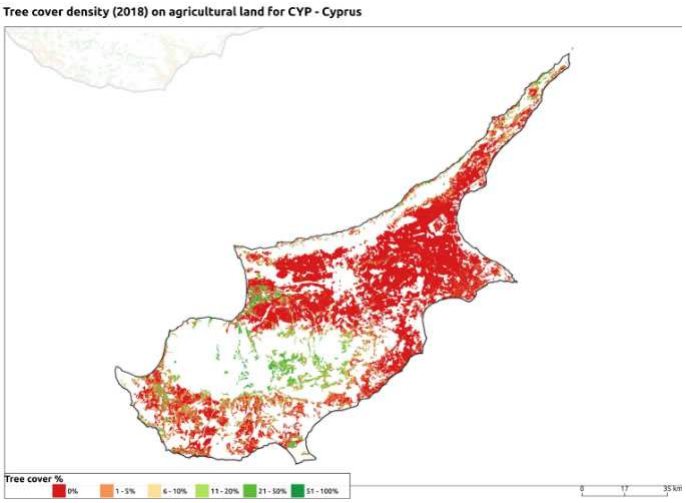


Figure 3. Tree cover density in Cyprus on grassland/cropland, using Copernicus and Corine 2018 data (100m pixels). Intense red colours indicate no tree cover.
Author: DigitAF Project | © CC-BY

Cyprus	LF - Selected	LF - Protected
1 Buffer Strips		
2 Cairns		
3 Cultural Features		
4 Ditches		
5 Field margins, patches etc		
5.1 set aside strips	y	
5.2 field margins	y	
6 Hedgerows/individual or group of trees/ trees in rows		
6.1 Hedgerows		y
6.2 Trees in Line		y
6.3 groves/copses		y
6.4 individual trees		y
6.5 scrub and forest edges		
7 Land lying Fallow	y	
8 Others		y
9 Small Ponds		y
10 Small Wetlands		y
11 Stonewalls		
12 Streams		
13 Terraces		

Figure 4. Landscape features in the Cypriot CAP Strategic Plan. Trees, hedges, lines, groves are protected but they don't count to the GAEC-8 area target.
Author: EURAF | © CC-BY

/// Always Moving Forward ///

EMISSION TARGETS. The EU LULUCF Regulation, (2023/839) allocates Cyprus a net emissions target of -352 KtCO2e/yr by 2030, a 22% increase compared to -289 KtCO2e/yr in 2016-18. The Energy and Climate Plan (2023-2030) gives few details of how this will be achieved, except for "planting 3 million trees by 2030", an almost impossible target given that only 50 hectares of afforestation is mentioned in the CAP Strategic Plan (2023-29).

CARBON CERTIFICATION AND AGROFORESTRY. Land use in the Republic of Cyprus (601.82hka from the total 924.2 kha) is dominated by forests (26.4%), woody cropland (20.3%) and woody grassland (17.2%) (NECP 2023-2030). The government has now adopted a wider definition of "permanent grassland", which can permit basic payments on areas with edible shrubs but no grass, potentially leading to an expansion of silvopastoralism. More work is needed to quantify carbon sequestration (e.g. Vourdoubas 2020) and to extend dryland tree-planting (e.g. LIFE-Agroassis). Hopefully, the Government's 3 million trees target will be helped by the forthcoming EU Carbon Removals Certification Framework (CRCF), and the ResAlliance project has contributed with input to the section of in this framework on the monitoring, reporting and verification of agricultural soils and agroforestry.

Further information

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Acknowledgment / Contribution

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Authors: Gerry Lawson | **Partners:** EURAF – European Federation of Agroforestry

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Agroforestry in the Greek Agricultural and Climate Plans

The Greek CAP Strategic Plan (2023) has more than 1300 pages. It provides a national definition of agroforestry, and agroforestry is also discussed in the Greek draft (2024) National Energy and Climate Plan.



Figure 1. Olive agroforestry in western Greece.
Author: Hellenic Agroforestry Network | © CC-BY



Figure 2. Trees and shrubs planted on parcel and sub-parcel boundaries in hilly agroforestry systems of northern Greece.
Author: Hellenic Agroforestry Network | © CC-BY

/// Context ///

The Greek CAP Strategic Plan (Section 4.1.2) gives a very detailed definition of agroforestry: Systems with scattered trees or trees in rows, or on the margins of plots. They can be either forest trees (oaks, pines, poplars, cypresses) or fruit trees (citrus, apple and stone fruit trees, acacia trees), olives, carob and mastic trees. They can be combined with the cultivation of cereals, horticultural crops, fruit and vegetables and/or grazing. Trees, if planted in rows, should have a minimum distance of 10 metres between rows, the distance between trees in the same row should be greater than 4 metres. Trees may also be present at the boundaries of the field in the form of a living fence to protect the agricultural crop from the wind and to create a zone that will support wildlife. The maximum number of trees is 250 trees/hectare. Agroforestry also includes partially forested areas (sparse forests) of pasture with the tree cover up to 40% and understorey with herbaceous and woody vegetation. In this case the minimum tree density may be 5 trees/hectare and the maximum 40 trees/hectare depending on the slope, tree species and climatic conditions.

There are no specific payments in Greece to support new agroforestry, but hedgerows, trees in line, groves/copses, individual trees are mapped in farmers annual returns and are eligible for basic payments (see Figure 4), and a small ecoscheme (P1-41.5) pays 100€ hectare/yr to improve existing silvoarable or silvo-pastoral areas.

/// Solution for a Resilient Future ///

BETTER MONITORING. The Greek Land Parcel Information System (OPEKEPE) data is not made available in the EU Inspire Portal or in the Member States Geoportal. This makes it difficult to identify the areas of trees on agricultural land. CAP Result Indicator 17, which is intended to indicate the areas of trees planted for afforestation (17.1), reforestation (17.2), agroforestry (17.3) and woody landscape features (17.4) gives only a single figure (350,000 hectares), with no breakdown. Output Indicator 16, shows annual payments made for tree-planting, but does not split the planned exoenditure between afforestation and agroforestry. Impact Indicator 21 should give the area of Landscape Features, but is not yet available for Greece.

WIDER IMPLEMENTATION. Although Greece has around 1.6 Mha of agroforestry (den Herder et al. 2015), it also has extensive “tree deserts” (Figure 3). These are areas of cropland and grassland with extremely low tree-crown-cover, and tend to be in areas with mineral-soils and high environmental pressures. Establishment of agroforestry in provinces with greatest “tree deserts” should be given priority. The Greek CAP Strategic Plan lists many ecoschemes, and measures for investment and agri-environment, but, surprisingly the only support for agroforestry is for the improvement of existing agroforestry through a rather small ecoscheme.

KNOWLEDGE SHARING. The strengths of agroforestry policy in Greece are summarised in EURAF Policy Briefing #37 and in Tsiakiris (2023) as: a) one of the largest areas and longest-established areas of agroforestry in Europe; b) extensive literature on agroforestry in permanent crops like vines, olives and fruit trees; c) increasing recognition of the importance of agroforestry for climate-mitigation and adaptation; d) holding in October 2024 of the first Pan-Hellenic Agroforestry Conference and publication of multi-author guide to agroforestry. The weaknesses are: a) no implementation of establishment or maintenance support for agroforestry; b) lack of advertising and confusion over the rules for the agroforestry ecoscheme, c) incomplete recording of agroforestry and landscape features in the Greek LPIS system (OPEKEPE); d) no clarity on whether agroforestry is eligible for any of a wide range of potential Pillar II measures; e) uncertainty over eligibility for basic payments on parcels with trees.

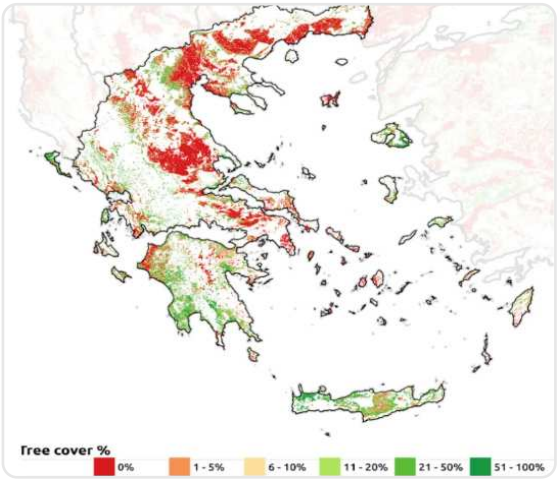


Figure 3. Tree cover density in Greece on grassland/cropland, using data from Copernicus and Corine from 2018 (100m pixels). Intense red colours indicate that the pixel has no tree cover.
Author: DigitAF Project | © CC-BY

GREECE	LF - Weight	LF - Selected	LF - Protected
1 Buffer Strips			y
2 Piles of stones as landmarks	1	y	y
3 Cultural Features	1.5	y	y
4 Ditches	2	y	y
5 Field margins and patches	1.5	y	y
6 Hedgerows/individual or group of trees/ trees in rows			
6.1 Hedgerows	2	y	y
6.2 Trees in Line	2	y	y
6.3 Groves/copses	2	y	y
6.4 Individual trees	2	y	y
6.5 Scrub or forest margins			
7 Land lying Fallow	1	y	
8 Others			
9 Small Ponds	1.5	y	y
10 Small Wetlands	2	y	y
11 Stonewalls	1.5	y	y
12 Streams	1.5	y	y
13 Terraces	2	y	y

Figure 4. Landscape features (m2) in the Greek CAP Strategic Plan: showing weighting for the GAEC-8 area targets, features selected and whether protected.
Author: EURAF | © CC-BY

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EMISSION TARGET. The EU LULUCF Regulation, (2023/839) allocates Greece a net sequestration target in the land-sector of 4.373 MtCO2e/yr by 2030, which is 36% more than the baseline in 2016-18. The Greek National Energy and Climate Plan, NECP (2021-2030), suggests that Greece will meet this through forest management (2.6Mt), crop management (1.5Mt) and land conversion to grassland (0.6Mt), but it gives no target for agroforestry. Nor does the National Forest Strategy (2018-2038). A tree-planting target is given in the CAP Strategic Plan (350,000 hectares over 6 years) but there is no separate figure for agroforestry.

CARBON CERTIFICATION AND AGROFORESTY. The book "Reviving Agroforestry Landscapes in the Era of Climate Change" emphasises the role of agroforestry in carbon-farming, but it is difficult to find sequestration measurements from agroforestry systems in Greece. The carbon-farming studies which exist, e.g. Vourdoubas (2020), suggest total soil and biomass sequestration rates of 1-3 t carbon/ha/yr (see EURAF Policy Briefing #26). More field work is needed to input to the draft EU "Delegated Act" on the Monitoring, Reporting and Verification of Carbon-Farming, particularly the section on "Agricultural Soils and Agroforestry".

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Agroforestry in the Italian Agricultural and Climate Plans

The Italian CAP Strategic Plan provides a national definition of agroforestry and support for planting, but it is hardly mentioned in the Italian National Energy and Climate Plan. Will carbon-farming certification bring a resurgence of agroforestry?



Figure 1. Hens ranging in olive trees in Umbria.
Author: Adolfo Rosati (CRE) and Piero Paris (IBAD-CNR) | © CC-BY



Figure 2. Cover Photo from "Agroforestry in Italy: an opportunity for agricultural holdings" (AIAF). Published in Italian in September 2023, under the auspices of the Rete Rurale Nazionale 2014-2020.
Author: AIAF Italy | © CC-By

/// Context ///

The Italian CAP Strategic Plan (Section 4b-2) defines agroforestry as "A land use system in which there are, in the same area, associations of tree vegetation with extensive agricultural and livestock crops and production in which wood and secondary forest products can also be obtained". A limit of 250 plants per hectare is given, but the area of the tree-crowns does not reduce the parcel-area eligible for basic payments (BISS), provided that agricultural production remains "sustainable".

There are several payments which farmers may receive for agroforestry, including ecoschemes in Pillar I and rural development payments in Pillar II. In summary:

- All types of woody-landscape-feature "Good Agriculture and Environmental Conditions (GAEC-8)" are implemented, i.e. hedgerows; trees in line, groves/copses, individual trees, and farmers are expected to map these these area in their annual CAP returns. These areas are fully eligible for basic payments (see Figure 4 and EURAF Policy Briefing #21).
- Five eco-schemes give annual payments to farmers in all regions. Two are focused on permanent crops like fruit-trees and olives, but do not specifically mention agroforestry.
- Twenty-nine "Agri-environment-Climate Measures" (Article 70) and 38 "Investment Measures" (Article 74/75) are implemented, and several could be of benefit to agroforestry but only SRD05 one specifically mentions "agroforestry" and this is implemented only in six regions.

/// Solution for a Resilient Future ///

BETTER MONITORING. The Italian Land Parcel Information System (SIPA) data is not made available in the EU Inspire Portal or in the Member States Geoportal. This makes it difficult to identify the areas of trees on agricultural land. CAP Result Indicator 17, which is intended to indicate the areas of trees planted for afforestation (17.1), reforestation (17.2), agroforestry (17.3) and woody landscape features (17.4) gives only single figure (50,159 hectares), with no breakdown. Output Indicator 16, shows annual payments made for tree-planting, but does not split the planned figure (73,568 hectares) between afforestation (imboschimento) and agroforestry (agroforestazione). Impact Indicator 21 should give the area of Landscape Features, but is not yet available for Italy.

WIDER IMPLEMENTATION. Although Italy has around 1.4 Mha of agroforestry (den Herder et al 2015, Paris et al 2019), it also has extensive "tree deserts" (Figure 3). These areas of cropland and grassland have extremely low tree-crown-cover, and tend to be in areas with mineral-soils and high environmental pressures. The CAP Strategic Plan contains explicit and potential support for agroforestry in ecoschemes, investment measures and agri-environment climate measures. However, not all autonomous regions implement this support, those with most "tree deserts" should give agroforestry priority.

KNOWLEDGE SHARING. The strengths of agroforestry policy are summarised in EURAF Policy Briefing #39 and Rivieccio et al. (2024) as: a) one of the largest areas and longest-established areas of agroforestry in Europe; b) extensive literature on agroforestry in permanent crops like vines, olives and fruit trees, c) increasing recognition of the importance of agroforestry for climate-mitigation and adaptation, d) holding in 2023 of the first Italian National Agroforestry Conference and publication of multi-author guide to agroforestry. The same authors summarised the weaknesses as: a) implementation of agroforestry policy options by only 6 regions; b) lack of advertising or even opening of the funding measures; c) confusion amongst officials and farmers over the rules and conditions; d) incomplete recording of agroforestry and landscape features in the Italian LPIS system (SIPA); e) no mention of agroforestry in additional Pillar II measures which could support it.

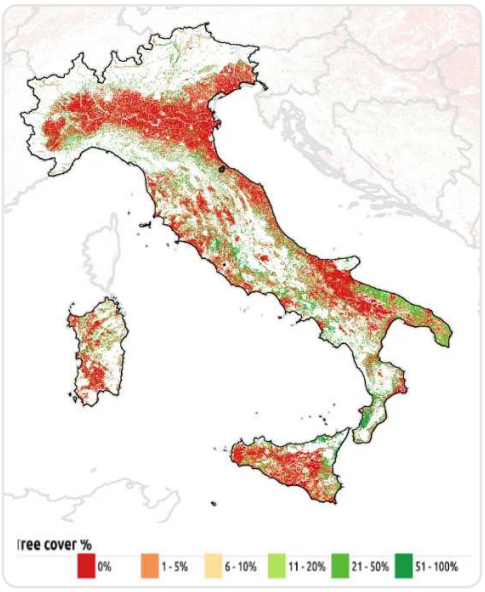


Figure 3. Tree cover density in Italy on grassland/cropland, using data from Copernicus and Corine from 2018 (100m pixels). Intense red colours indicate that the area has no tree cover.
Author: DigitAF Project | © CC-BY

ITALY	LF - Weight	LF - Area	LF - Protected
1 Buffer Strips	1,5	y	y
2 Cairns			
3 Cultural Features			
4 Ditches	2	y	y
5 Field margins and patches			
5.1 field margins (m)	1,5	y	y
6 Hedgerows/individual or group of trees/ trees in rows			
6.1 Hedgerows	2	y	y
6.2 Trees in Line	2	y	y
6.3 Groves/copses	1.5	y	y
6.4 Individual trees	1,5	y	y
6.5 Scrub			
7 Land lying Fallow	1	y	
8 Others		y	y
8.1 Monumental trees	1,5	y	
9 Small Ponds (a surface area of 3,000 m2 or less)	1,5	y	y
10 Small Wetlands			
11 Stonewalls	1	y	y
12 Streams			
13 Terraces	1	y	

Figure 4.: Landscape features in the Italian CAP Strategic Plan: showing weighting for contribution to the GAEC-8 targets, features selected and whether protected.
Author: EURAF | © CC-BY

/// Always Moving Forward ///

EMISSION TARGETS. The EU Land Use, Land Use Change and Forestry Regulation, (2023/839) allocates Italy a carbon-capture target in the land-sector of 35.758 MtCO2e/yr for 2030, but the Italian National Integrated Energy and Climate Plan (NECP 2021-2030) projects that LULUCF net sequestration in 2030 will be only 28.4 MtCO2e, having risen from 21.2 MtCO2e in 2022. Surprisingly, tree planting areas or afforestation/agroforestry sequestration targets are not mentioned in the NECP. Specific Action 9 in the Strategia Forestale Nazonale (2022) aims by 2025 to increase the area of "agroforestry, agroforestry systems and cork-farming" by 15% compared to 2025.

CARBON CERTIFICATION AND AGROFORESTRY. Agroforestry trials at Casaria farm in Padua province have demonstrated that 50-100 poplar trees per hectare can store 1-4 tonnes of carbon per hectare per year in the wood alone (Mezzalira et al., 2021). This and other studies reviewed in EURAF Policy Briefing #26 show that agroforestry provides a viable solution for carbon farming. The EU Carbon Removals Expert Group is expected to draft three "Delegated Acts" in 2026 giving Monitoring, Reporting and Verification Rules for a) Agricultural Soils and Agroforestry, b) Sustainable Forest Management and c) Wetland Rewetting.

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Type of Solution: Governance Sector: Agroforestry
Good practice(s): Soil management, Management alternatives, Ecosystems services, Financing

Agroforestry in the Spanish Agriculture and Climate Plans

The Spanish CAP Strategic Plan provides a national definition of "agroforestry", and sets out how autonomous regions can monitor it and provide support.



Dehesa in Extremadura in summer, showing the grass still green under the evergreen oaks (Quercus ilex).
Author: Gerardo Moreno | © CC-BY



Extensive grazing generates important economic, social and environmental benefits, including reductions in fire risk and intensity of wildfires.
Author: Manuel Bertomeu | © CC-BY

/// Context ///

The Strategic Plan for the Spanish Common Agricultural Policy (PAC) indicates that “agroforestry systems” on arable land should have less than 100 trees/ha, whereas in permanent pasture it is defined more flexibly based on remotely-sensed information on tree-crown-cover and a “coefficient of grazing eligibility” which gives the percentage of basic payments due per land-parcel. There are many additional payments which farmers and foresters can receive for agroforestry, but the situation is complex and differs between the Autonomous communities. In summary:

- There are nine elements of “conditionality” (Good Agricultural and Environmental Conditions) (GAEC) which farmers must follow to get basic payments. Three of these are relevant to agroforestry: GAEC-8 (maintaining landscape features), GAEC-1 (preserving ratios of permanent pasture) and GAEC-9 (ban on converting permanent pasture in Natura 2000 sites).
- There is also the new concept of “eco-schemes”, with nine in total and six which may be relevant to agroforestry, particularly in relation to extensive grazing and maintaining vegetative cover in permanent crops.
- Finally there are 28 “investment” or “agri-environment-climate measures”. At least 13 of these could potentially be used for agroforestry, but only two of these explicitly mention agroforestry in their titles. Agroforestry-related measures have been activated in 10 – 11 autonomous regions, and all regions have activated at least 4 of the 13 measures.

/// Solution for a Resilient Future ///

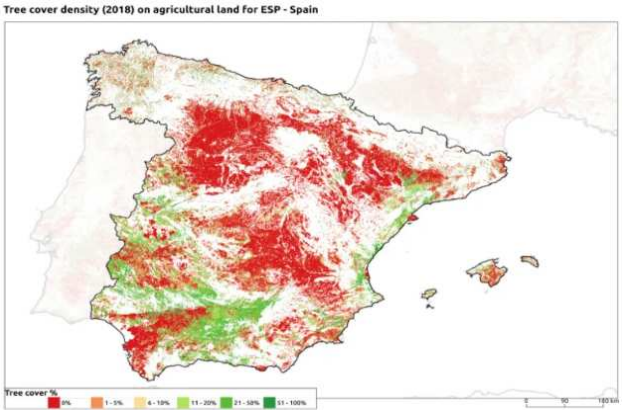
BETTER MONITORING. The Spanish Land Parcel Information System (SIGPAC) is one of the best and most open in Europe. It is almost unique in including both agricultural and forest parcels, and has two land-use categories for silvopasture (pastures-with-trees and pastures-with-shrubs). This 100% coverage of rural land use gives the fine-scale needed to monitor tree cover both inside and outside of forests. Furthermore it allows detailed tracking of CAP statistics directly supported by Member States, for example, R.17 – area of supported afforestation and agroforestry, O.16 – area of afforestation and agroforestry receiving annual maintenance payments and I.21 – area of landscape-features recorded by member states. Spain has the opportunity to mark these areas at high-resolution in their SIGPAC system, and give an example to the rest of Europe on how CAP monitoring can be integrated with national GHG emissions reporting and farm-scale carbon certification.

WIDER IMPLEMENTATION. Although Spain has the largest area of agroforestry in the EU (including around 8 Mha of dehesa) it also has extensive “tree deserts” (see map). These are the areas with mineral-soils suffering from greatest environmental pressures: where agroforestry planting efforts need to be focused. The ten mainland provinces with most “zero-tree-hectares” are Valladolid (92.8%), Zaragoza (91.4%), Albacete (90.9%), Cuenca (89.4%), Segovia (89.3%), Palencia (88.8%), Soria (88.5%), Burgos (87.2), Teruel (87.1%) and Zamora (84.8).

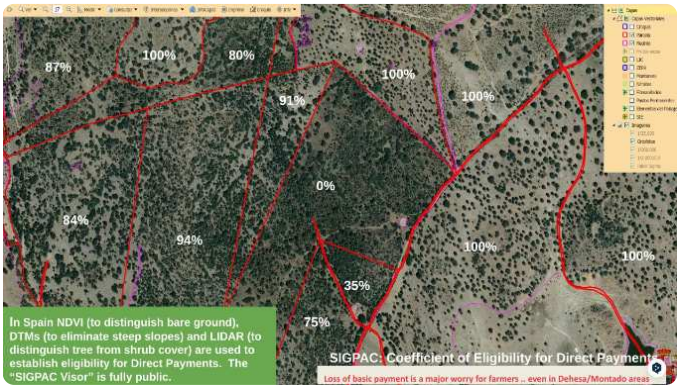
KNOWLEDGE SHARING. Representatives of several agroforestry projects in Spain recently summarised in EURAF Policy Briefing #44 the STRENGTHS of agroforestry as: a) explicit recording of silvopastoral parcels in the SIGPAC system and integration with forestry details; b) largest area of agroforestry in Europe; c) extensive literature on the importance of the agroforestry for climate-mitigation and adaptation (e.g. wildfire reduction, soil protection, hydrological regulation,

conservation and connectivity of biodiversity, maintenance of landscape elements etc), d) growing numbers of innovative agroforestry projects and practitioners. WEAKNESSES were a) incomplete reporting of new areas of agroforestry established with CAP support, b) confusion over threshold definitions of agroforestry, c) there is no mention of agroforestry in many Pillar II measures which could support it; d) there is confusion over the meaning of “landscape-features” in Spain. e) the current low profitability of silvopastoral systems hinder generational change, f) there is segregation between forestry and agricultural training in universities and technical colleges.

PUBLIC SUPPORT. The new CAP Strategic Plan contains explicit and potential support for agroforestry in ecoschemes, investment measures and agri-environment-climate measures. Not all autonomous regions implement this support however and data on the uptake and eventual impact of these measures is difficult to obtain.



Tree cover density in Spain on grassland/cropland, using data from Copernicus and Corine from 2018. Intense red colours indicate that the area has Zero-Trees.
Author: DigitAF Project | © CC-BY



The Spanish Land Parcel Identification System (SIGPAC) records % eligibility of grassland with trees or shrubs for basic payments. It is a fantastic resource.
Author: MAPAMA | © CC-BY

/// Always Moving Forward ///

Introduction of voluntary certification for agroforestry carbon farming could be the missing link to help establish new agroforestry areas and better maintain existing ones . They will also help the regional and national authorities to meet targets in a number of climate plans and regulations, e.g. :

1. The EU Land Use, Land Use Change and Forestry Regulation, which allocates Spain a carbon-capture target of 43.6 MtCO2e/annum for 2030 in the land-sector, which Spain is unlikely to achieve without a massive increase in both afforestation and agroforestry
2. The revised Spanish National Energy and Climate Plan (NECP) which emphasised tree regeneration in silvopastoral systems, controlled grazing in strategic areas to prevent forest fires, as well as afforestation, development of land contracts through public-private partnerships that support forest management and grazing in forest landscapes, and a favourable tax regime to support grazing in forests and forest management.
3. Regional measures like the Climate Credit System of Catalonia which supports forest climate credits (which calculate the effect of forestry practices on carbon, water and biodiversity) and agricultural land climate credits. These regional measures include voluntary carbon certification, sustainable forest management, silvopastoralism, afforestation and agroforestry.

Further information

- Bertomeu, M, Coello, J, Lawson, G, Armengot, L, Baiges, T, Borràs Calvo, G, et al. 2023. Agroforestry in CAP Strategic Plans – Spain. European Agroforestry Federation. Report No.: 44. Version 1. https://zenodo.org/records/10903406 (Versions of this are available in English and Spanish to collect comments for future editions)
- The draft Spanish Energy and Climate Plan (July 2023), especially the sections describing the contribution of the Land Sector to LULUCF and agricultural GHG emission targets and plans to support nature-based approaches to fire mitigation.

Acknowledgment / Contribution

- This factsheet is based on a EURAF Policy Briefing #44, coordinated by EURAF with participation of a range of projects including: LIFE Montserrat Project (2014-19), LIFE Dehesa/Mountado Adapt (2016-22), Mosaico Project (2017-23), LIFE MIDMACC project (2019-24), PRIMA Transition (2021-24), LIFE AgroForAdapt project (2021-26).

Authors: Gerry Lawson; Jaime Coellho; Manuel Bertumeo | **Partners:** EURAF – European Federation of Agroforestry

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ResAlliance

Carbon farming: is it the game-changer for agroforestry?

Agroforestry farmers get little support from the Common Agricultural Policy, but certified carbon farming payments will encourage its use. Here we make suggestions for the certification rules.

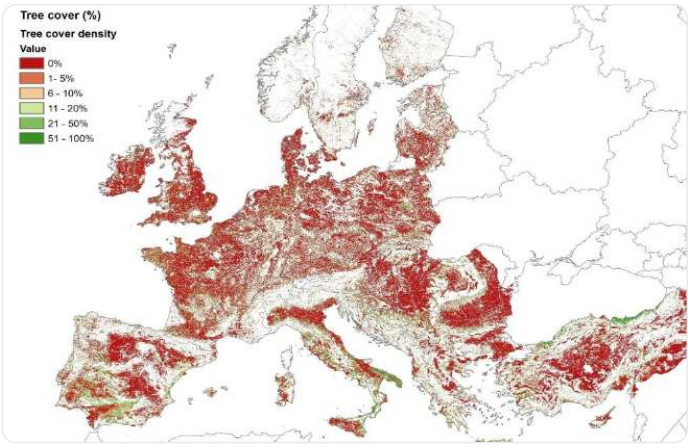


Figure 1: Areas with zero trees (deep red) on European grassland/cropland (Corine and Copernicus data 2018). New tree planting should be focused here.
Author: DigitAF Project | © CC-BY-NC

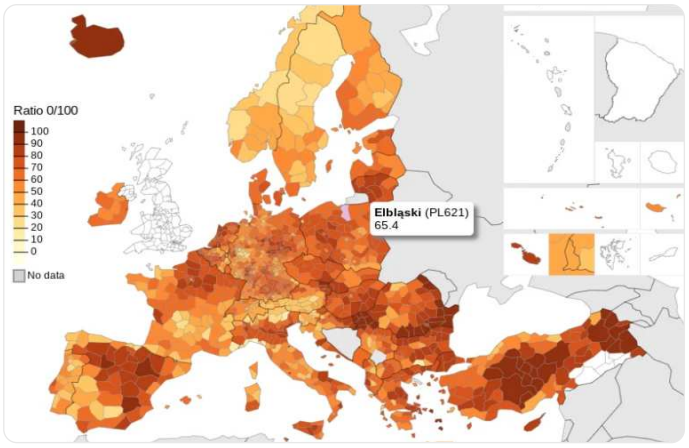


Figure 2: Provinces (NUTS3) with fewer trees on grassland/cropland areas (dark brown). Tree planting in these areas will bring greatest environmental benefit.
Author: DigitAF Project | © CC-BY-NC

/// Context ///

Funding for agroforestry is provided through the Common Agricultural Policy only for BE-FL, CZ, DE, EL, ES, IT, PI, PT and SK. However, even these Member States make very small sums available, and seldom publish the planting area targets.

Nevertheless, large-scale planting of agroforestry could be encouraged by agreement on the EU Carbon Removals Certification Regulation (CRCR – 10.4.24). This agreement on the draft text will be followed by publication of an initial version of the Monitoring Reporting and Verification (MRV) rules for the certification of carbon-farming by October 2024. Three sets of rules are envisaged: a) agricultural soils and agroforestry, b) rewetting of peatlands, c) sustainable forest management.

EURAF is cooperating with several projects to input to these MRV rules. We recommend that the initial planning and establishment of agroforestry can be funded through the CAP, with successful plantations being accepted into voluntary or statutory certification from year 6 onwards. For example

- in year 0 tree-planting would be planned and baseline soil samples taken using “ecoschemes”
- in year 1 tree-planting would be supported through CAP “investment measures”

Agroforestry is funded in the CAP of only seven Member States. Carbon farming support would make it viable everywhere.

Parklands, hedges, tree-lines and copses will benefit farms by bringing soil carbon, environmental improvement and increased revenues: especially in the “tree desert” areas of Europe.

- in years 2-5 annual support would continue as a CAP “agri-environment-climate measure”.
- in year 6 the agroforestry area would be “adopted” into an approved voluntary carbon farming scheme, and a carbon-credit given according to observed tree-growth, sampled soil carbon changes and modelled emissions reductions.

The draft CRC Regulation recommends use of the national CAP Land Parcel Identification System (LPIS) to identify carbon-farming parcels. CAP/Copernicus orthophotos and Sentinel 1-2 images (link) will be used to monitor tree growth and soil carbon changes. Removals and reductions from the crop/grass alleys and tree-strips will be given in a combined report at the end of each 5-year monitoring period. The “activity period”, used for the overall calculation of carbon credits, will span the economic rotation of planted trees. Furthermore, if farmers elect to class the tree lines as statutory “Landscape Features” they will be protected in the same way as forest trees – giving a guarantee of “permanence” to the agroforestry system, and a potentially higher unit value for the carbon.

95.2 million hectares of cropland/ grassland in the EU-27 have zero trees, and 117.9 million hectares have less than 10% tree-crown-cover. Planting 10% of this by 2040 needs 750kha/yr. Is it possible?

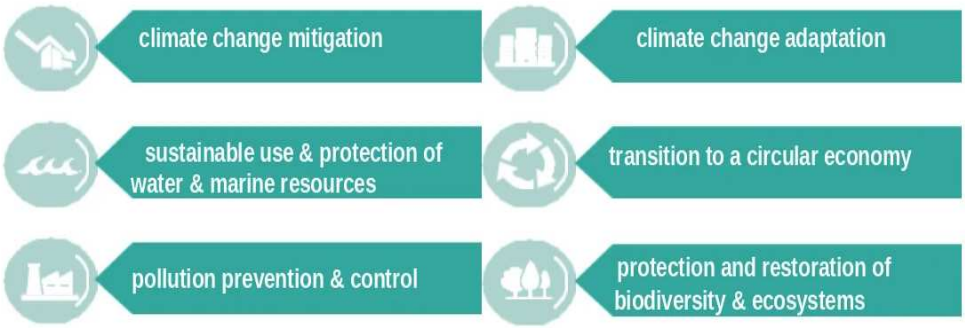


Figure 3: The six types of sustainability listed in the EU Sustainable Finance Initiative. The CRCF focuses on mitigation. (See EURAF Policy Briefing #28).
Author: European Commission | © CC-BY

/// Solution for a Resilient Future ///

To gain EU certified status, projects must meet 16 criteria (A-P) given in Annex I of the Carbon Removals Certification Regulation (CRCR). The first 14 concern removals and reductions – and can be met for agroforestry (AF) using existing methods. The final two concern sustainability monitoring, and new methods need to be developed – see next section.

A. Description of "activity" and the practices and processes covered, including the activity and monitoring period. For the purposes of the CRCR, agroforestry wil be defined as "a land use system where trees and/or shrubs are purposefully grown in combination with agriculture in an agricultural parcel or on its boundaries". The Monitoring Period will be 5 years, and the Activity Period ("rotation length") will balance economics with long-term carbon capture and emission reductions.

B. Rules for identifying carbon removal sinks and GHG emission sources. Will follow IPCC (2003 and 2019) guidance including "temporary" net carbon removals, GHG net-emissions and predicted harvested wood products and biochar. Options for monitoring of GHG reductions from slurry and enteric fermentation will be included.

C. Rules for calculation of a "standardised baseline". Must be *"representative of the standard performance of comparable practices and processes in similar social, economic, environmental and technological circumstances and take into account the geographical context, including local pedoclimatic and regulatory conditions"*. This is not practical for AF, because of insufficient data in different pedoclimatic conditions. Project baselines will therefore be used.

D. Rules for calculating total carbon removals. Will follow IPCC methodology, supplemented by best practice for measurement of carbon removals and GHG reductions in tree-lines and the soils of agricultural alleys. Monitoring methods (e.g. CIFOR-ICRAF 2011), models (e.g. Hi-sAFe, CARAT), and existing standards (e.g. LBC and VERRA) will be described.

E. Rules for calculating LULUCF soil emissions. Will include all carbon fluxes and GHG emissions in forests, plus carbon fluxes in all land uses and changes (Chapter 7 of national GHG Inventory Reports).

F. Rules for calculating agricultural soil emissions. Will include all GHG emissions in agricultural land (Chapter 6 of national GHG Inventory Reports), but not wetlands.

G. Rules for calculating GHG associated emissions – Will include direct and indirect greenhouse gas emissions from soils and indirect land use change (ILUC). AF reduces both nitrate leaching and volatilization of ammonia – thereby lowering indirect N20 emissions. Land Use Change effects are unlikely since AF will continue as cropland or grassland.

H. Rules for updating the standardised and activity-specific baselines. WIll include collaborative methodologies and metadata standards for agroforestry in different climate, management and soil conditions, and will eventually allow "standardised baselines"

I. Rules to address uncertainties. AF systems are complex, and quantification of uncertainty is vital. Monitoring will follow IPCC Tier 3 methods linked to process-based modelling and evaluation of model parameter sensitivity (Paul et al 2023, Negash et al 2015).

J. Rules to carry out specific additionality tests. Will be needed for projects using "activity-specific" baselines. Agroforestry projects should demonstrate: a) sustainability standards which exceed statutory CAP "conditionality" and b) lack of long-term financial viability without carbon payments.

K. Rules on monitoring and mitigation of any risk of release of stored carbon. AF projects will declare trees as "productive-landscape-features", which cannot be removed without felling licences from forest authorities. Risks of fire are much lower in agroforestry than in conventional forestry.

L. Rules on appropriate liability mechanisms for release of stored carbon. All registered operators will require insurance but premiums will be lower for AF because of lower fire risk.

The EU Carbon Removals Regulation gives "headline" monitoring criteria for carbon-farming - do these fit agroforestry?

Agroforestry and soil-carbon certification can build on initial CAP measures: eco-schemes (baselines - yr 0), investment (yr 1-establishment) and agri-environment-climate (yr 2-5 - maintenance).

Tree location	Agroforestry system	Agroforestry practice	
		Agricultural land	Forest land
In parcels	Silvopastoral	1 Wood-pasture	9 Forest-grazing
	Silvoarable	2 Tree-alley-cropping 3 Coppice-alley-cropping 4 Multi-layer gardens	10 Multi-layer-gardens
	Permanent crop	5 Orchard intercropping 6 Orchard grazing	
	Agro-silvo-pasture	7 Alternating cropping and grazing	
Between parcels	Landscape features	8 Hedges, trees in groups, trees in lines, individual trees	
Settlements	Urban agroforestry	11 Homegardens, allotments, etc.	

Figure 4: The Agroforestry Typology used by the European Agroforestry Federation, and published in all EU Languages. | Author: EURAF | © CC-BY

M. Rules for operationalising the procedures at the end of monitoring periods. Will measure stored carbon in soil and timber, backed by evidence from LPIS orthophotos, remote sensing tools and certification for harvested wood products and biochar.

N. Rules on monitoring of soil emission reductions. Field or lab measurements of N2O and CH4 are difficult and costly. Hence agroforestry projects will mainly rely on published and verified biophysical models.

Voluntary carbon certification will then continue funding from year 6 onwards, with an option to withdraw from the scheme every 5-years, unless the farmer declares the trees as "landscape-features".

/// Always Moving Forward ///

The final two CRC MRV Rules in Annex I (O and P) relate to Article 7 (Sustainability), which lists six objectives.

- *Climate change mitigation beyond net carbon removal benefit and net soil emission reduction*
- *Climate change adaptation*
- *Sustainable use and protection of water and marine resources*
- *Transition to a circular economy, including the efficient use of sustainably sourced bio-based materials*
- *Pollution prevention and control*
- *Protection and restoration of biodiversity and ecosystems*

New techniques are needed for projects to demonstrate *"no significant harm"* (Criteria O) for objectives 2-5 above and a *"co-benefit beyond no significant harm"* (Criteria P) for objective 6.

(1) Climate change mitigation beyond net carbon removal and soil emissions. The original draft of the CRCR did not include emissions from (a) soils, (b) slurry or (c) enteric fermentation. The revised draft now includes (a), and is likely to be amended in 2025 to include (b) and (c). When this happens, UNFCCC GHG climate change mitigation reporting requirements will be fully met.

How will sustainability be monitored and could "high-biodiversity carbon-farming" get a higher price for carbon?

Payments for carbon sequestration can provide the impetus for large-scale introduction of agroforestry on "tree-deserts" and degraded land across Europe. Now we need to agree the monitoring rules!

(2) Climate change adaptation. Agroforestry has a range of benefits for adaptation to climate change. These include a) increased soil organic matter, b) reduced soil erosion, c) increased fertility and resource use efficiency; d) greater resistance to droughts and floods; e) diversified landscapes and biodiversity; f) reduced pest and disease pressure; g) maintained crop yields and animal welfare; h) increased resilience to extreme events – including wildfires and storms; i) improved economic resilience; and j) reduced groundwater and air pollution. Surprisingly, agroforestry is mentioned in less than half of the Adaptation Strategies of EU Member States. See EURAF Policy Briefing #27.

(3) Sustainable use and protection of water resources. Agroforestry in upland catchments increases the water holding capacity of soils and reduces stormwater flows. Riparian strips and lines of trees, established in a network of berms and swales, contribute to floodwater dispersal and management. In drought-prone areas, trees can be established after contour ripping, and combined with lagoons to conserve water supply locally.
Areas high tree-cover evaporate rainfall which falls in downwind catchments. That evapotranspiration helps cool landscapes. The opportunity for hydrologic bioengineering is great, and needs greater cooperation between local authorities, river-authorities and farmer groups in the planning and planting of agroforestry and landscape features. See draft Policy Briefing #64.

(4) Contribution to the circular economy. The circular economy in agriculture means food systems that build natural capital and allow nature to thrive. Agroforestry generates positive environmental outcomes for nature, while delivering a greater range of economic products, such as quality timber, biochar, wood-chips, and animal fodder. Agroforestry can be tailored to local contexts and merged with other practices such as more diverse crop varieties, keyline planting, cover crops, adaptive multi-paddock grazing, and living barns. See draft Policy Briefing #67.

(5) Pollution prevention and control. Agroforestry benefits soil health, water quality and atmospheric pollution directly by i) binding soils in place, reducing water erosion, ii) reducing wind speeds and windborne erosion, including atmospheric pollution from phytochemicals, iii) absorbing excess nutrients, and iv) slowing down pollutant leaching to groundwater. The EU Directive on Soil Monitoring will help standardise soil monitoring methods, and the EU Farm Sustainability Tool for Nutrients is being provided by MS to record field-by-field information on soil carbon, fertiliser use and soil nutrient content. See draft Policy Briefing #65.

(6) Contribution to the protection of biodiversity and restoration of ecosystems. EU CRCR co-legislators insisted that a positive co-benefit must be demonstrated for "biodiversity and ecosystem restoration" in carbon-farming. Detailed monitoring of biodiversity may be difficult in individual projects but management plans will focus on activities which are known to benefit biodiversity, together with continuing scientific research. Available scientific studies universally show biodiversity benefits of agroforestry compared to intensive agriculture, and a majority also show benefits compared to forest plantations. See draft Policy Briefing #66.

Rules are being developed by the EU Expert Group on Carbon Removals, and the ResAlliance project will be making submissions. Please use the ResAlliance Forum to make comments and keep in touch.

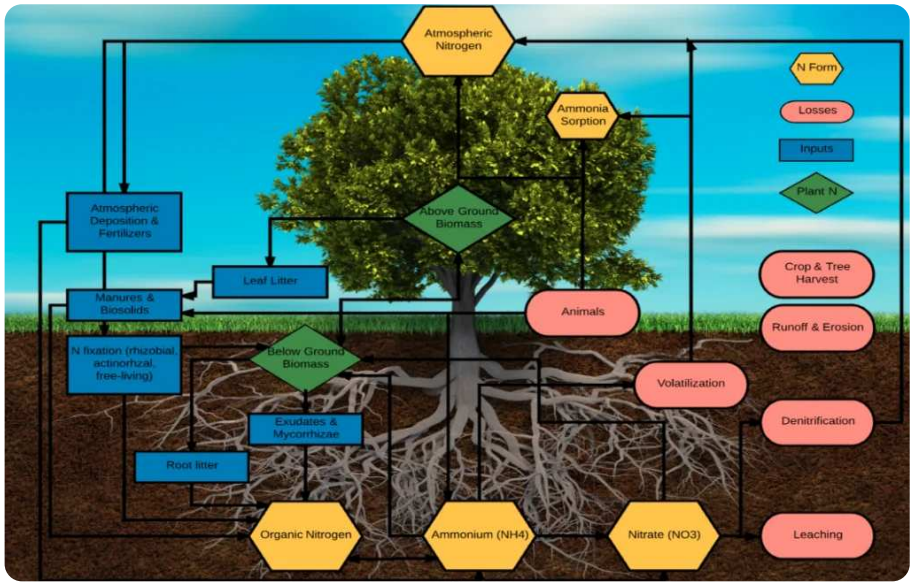


Figure 5: Trees increase soil organic matter and reduce direct emissions of nitrous oxide and indirect emissions of gaseous ammonia and nitrate in drainage.
Author: EURAF | © CC-BY

Further information

- Carbon Gap (2022) "A Guide to Carbon Removal" 2022 pdf
- CIFOR-ICRAF (2011) A protocol for modelling , measurement and monitoring soil carbon stocks in Agricultural landscapes. pdf
- DigitAF Project (2024) www.digitaf.eu
- EU Commission (2023) Updated LULUCF Regulation
- EURAF (2022) Policy Briefing #20 "Agroforestry & the Carbon Removals Framework"
- EURAF (2023) Policy Briefing #26 "Agroforestry and the 2040 AFOLU net-zero target.
- EURAF (2023) Policy Briefing #29 "Agroforestry and the Sustainable Finance Initiative".
- EURAF (2024) Policy Briefing #8 "Agroforestry for carbon farming in the EU"
- EURAF (2024) Press Release "Agroforestry: vital to Europe's Land Emissions Neutrality" 6.2.24
- EURAF (draft) Policy Briefing #64. Agroforestry for sustainable use of water resources.
- EURAF (draft) Policy Briefing #65. Agroforestry for pollution control.
- EURAF (draft) Policy Briefing #66. Agroforestry for biodiversity and the protection of ecosystems.
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- MVARC (2024) Interactive map of "tree deserts" in EU counties and provinces (NUTS3), Website
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Authors: Gerry Lawson | **Partners:** EURAF – European Federation of Agroforestry

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Type of solution: Governance Sector: Agroforestry, Forestry
Good practice(s): Management alternatives, Ecosystems services, Protection against biotic and abiotic hazards

Nature-based emission reduction and fire control measures in the climate plans of six Mediterranean states

All Member States (MS) were due to finalise their National Energy and Climate Plans (NECPs) by June 2024. What nature-based solutions were included for emission-reduction and wildfire-mitigation?



Figure 1. Goats grazing in Catalonia. Goats and pigs can clean almost any undergrowth. Native breeds of cattle will control regrowth after a prescribed burn.
Author: Gerry Lawson (EURAF) | © CC-BY



Figure 2. Cattle grazing in an official "forest": over-thinned Pinus sylvestris. Grazing can be better managed to allow forests successful silvopastoralism.
Author: Vasilios Papanastasis (HAN) | © CC-BY

/// Context ///

National Energy and Climate Plans contain strategies for decarbonisation, energy efficiency, energy security, internal energy market, research, innovation and competitiveness. They also should indicate how national emission targets contained in the updated Land Use, Land Use Change and Forestry (LULUCF) Regulation (2023) and the Effort Sharing Regulation (2023) will be complied with by the year 2030.

How Member States deal with the threat and impact of wildfires is crucial in meeting these emission targets, especially in the Mediterranean countries. From 2025 onwards, the LULUCF Regulation and the Emission Sharing Regulation removes a number of greenhouse gas emissons reporting flexibilities from Member States. This will make emission targets even more difficult to deliver, and should incentivise the move from fire-fighting to fire-mitigation using nature based solutions. These solutions will use grazing to control the undergrowth on forest land, and integrate the management of adjacent agricultural and settlement land within comprehensive municipal fire management plans. This approach implies a coordination of purpose across all central and local government departments and an unprecedented level of public and private involvement that makes land-management and fire-management one and the same thing.

NECPs show how MS will meet their energy and climate challenges. We focus here land sector emissions and wildfires.

Goat mismanagement caused significant damage to Mediterranean forests in the past. But, better herding allows forests and goats to coexist and brings mutual benefits, including wildfire control.

This summary compares the NECPs of six Member States. Each takes a different approach. Two countries (France and Spain) predict that they will fall far short of their 2030 emission targets in the land sector, but give a comprehensive analysis of the difficulties which climate change brings to their forest sector, and propose a range of mitigation actions, including agroforestry. Four countries (Portugal, Italy, Greece, Cyprus) estimate that they will meet or come close to their 2030 net emission targets, but with the exception of Portugal they don't give much detail on how their calculations were made, and what nature-based solutions are being applied to mitigate the risk of wildfires.

The EU Forest Strategy 2030 stresses risk management practices, such as integrated landscape fire management systems to increase forest resilience against wildfires, pests, diseases.

/// Solution for a Resilient Future ///

SPAIN is projected to miss its 2030 LULUCF target of -43.6Mt CO2 in 2030, and achieve only -34.0 to -35.0 MtCO2e. However, the NECP gives a long description of planned mitigation activities, including:

- Regeneration of dehesa systems.
- Promotion of poplars and native species to replace agricultural crops in flood-prone areas.
- Creation of forested areas.
- Silviculture to prevent forest fires
- Controlled grazing in strategic areas for forest fire prevention
- Promotion of sustainable forest management in conifers to maximise carbon absorption
- Hydro-forestry in areas at high risk of erosion.

For forests, mechanisms for action will be developed in future CAP Plans, including 3rd generation river basin management plans, harmonisation of fees for use of public water resources, promotion of public-private financing instruments for contracts to facilitate grazing on forest land, promotion of higher added value forest products, implementing priority actions for forest hydrological restoration. For agriculture, the emphasis is on regenerative agriculture and on the incorporation of woody residues into soils.

PORTUGAL is on track to achieve its LULUCF net removals of -1.358 MtCo2e in 2030, and reports achieving -6.29 MtCO2e in 2022, compared to only -390 MtCO2e in 2016-2018. The NECP has a strong emphasis on fire mitigation, based on the Landscape Transformation Programme (PTP) which focuses on areas with high fire hazards and is implemented by a combination of "Redevelopment and Landscape Management Programmes", "Integrated Landscape Management Areas", "Integrated Village Support Programmes" and "Parcel Aggregation Programmes", linked to a refreshed rural cadastre. Portugal also implements voluntary carbon certification and woodfuel harvesting to reduce forest-fuel loads.

FRANCE will miss its 2030 LULUCF net emissions target of -34.046 Mt by a long way. It projects only -18.00 Mt CO2e by 2020, even with additional measures. Net emissions were -27.343 Mt CO2e in 2016-18, but had fallen to -16.92Mt CO2e in 2022. This worsening trend is projected to continue up to 2050, reflecting a "severe mortality and growth crisis" in the French forestry sector "due to the effects of climate change (drought, heatwave) with increased mortality and reduced growth in forests affected by climate change (drought, fires, pests)". In response, France is implementing an array of public policies to enhance the carbon sink, including:

PT, EL, IT and CY predict LULUCF emissions in 2030 close to their targets. ES and FR predict big shortfalls, but have the best nature-based solutions for fire-mitigation and increased sequestration.



Figure 3. Intercropping of olives and wild asparagus in Italy. Chickens are proposed as a source of income while providing weed control and fertilisation.
Author: Adolfo Rosati (CREA) | © CC-BY

Wild asparagus, a shade-tolerant perennial, can be grown alongside olive trees. It thrives under the same climatic conditions, making it a low-impact crop that can boost local incomes.

- Tax incentive scheme for investment in forests.
- Forest and insurance investment account
- Forest fire control system
- Low-xarbon label to encourage carbon-sequestration schemes (11 methods already approved, with 3 in forestry)
- National forest and timber programme
- Action Plan for the recovery of the forest-based sector
- Forest and woodland research and innovation plan
- Law to strengthen prevention in the fight against forest fires
- Major efforts in the agriculture sector – with an Agroforestry Development Plan for trees in hedges and fields.

ITALY is projected to almost achieve its 2030 LULUCF target of -35.358 MtCO2e, with -34.900 MtCO2e projected. This will decline to -29.600 MtCO2e in 2035 however. Yet the draft NECP describes only briefly the policies and measures to support the LULUCF sector, including a carbon-farming initiative. Surprisingly, there is no mention of "wildfires" or "forest fires", or of "agroforestry". The 2018 law on Forests and Forest Supply Chains and its new guidelines on sustainable forest management are anticipated to improve carbon sequestration in forests. Similarly a white paper is in consultation on forest priorities in Italy.

GREECE expects to meet its LULUCF target of -4.373 MtCO2e, which is a 36% increase in removals compared to the years of 2016-18. It has assumed increasing sequestration in its forests through to 2050, although ever increasing damage from forest fires makes this seem optimistic. Greece has an excellent law to encourage forest-



grazing as a fire control mechanism, using detailed grazing-management plans.

CYPRUS has a LULUCF target of -0.352 MtCO2e in 2030 and projects that it will achieve -0.325 MtCO2e by this year, although net emissions in 2021 were only -0.240 MtCO2. No clear measures for nature-based mitigation of wildfire-risk or increased forest or agricultural sequestration are described in the draft NECP, other than a target of 300.000 tree-planting per year by 2030. The CAP Strategic Plan afforestation target is only 50 hectares.

Figure 4. Goats grazing in an olive meadow on the Greek island of Evia.
Author: FreePik | © FreePik

/// Always Moving Forward ///

- Whilst achievement of the French net LULUCF emission target by 2023 looks impossible, the French National Energy and Climate Plan gives excellent pointers for other countries: particularly since it mentions agroforestry 28 times! Mentions of agroforestry included:
- Valuing bioenergy where production of woodfuel, wood chips and biochar from hedgerows and in-parcel trees can increase the overall economics of agroforestry and provide an incentive for more intensive pruning and management. Rather than being included in the French Forestry Strategy, agroforestry is considered under the National Strategy for the Mobilisation of Biomass – where it is mentioned 27 times and identified as a potentially important source of employment, revenue and environmental benefit.
- Increasing use of catch and cover crops which grow after the main crop or alongside perennial crops – increasing to 4.8 Mha by 2030 – and recognising that these can be part of agroforestry systems – identifying a need to establish 120 000 hectares of in-parcel agroforestry before 2035.
- Increasing intra-parcel trees on grassland to reach 10,000 hectares by 2030.
- Pledging to protect permanent grassland keeping its area close to the present 96 Mha, including in agroforestry systems.
- Launching a second agroforestry development plan to follow the success of the 2015-20 Agroforestry Plan – keeping the same five strands – a) strengthening the research and extension knowledge, b) improving the regulatory framework, c) developing advice and training, d) understanding economic and social implications, e) promoting European and international approaches.
- Establishing the 'Plantons des haies !' initiative to encourages farmers to restore hedgerows – aiming to establish 7,000 km of hedges within 2 years and 50,000 km by 2030, in a 110M€ scheme.

France: the best example of integrating agroforestry into agricultural, environmental and climate plans.

- Encouraging the AFAC-Agroforestiers Label Haie programme – to encourage and reward good environmental services.
- Strengthening the 4:1000 programme which aims to increase carbon storage in soils by 0.4% globally, which brings together a wide range of international bodies in the Marrakesh Partnership for Global Climate Action.
- Developing carbon-farming levers where various CAP incentives favour trees on farms, including GAEC-8, investment measures and agri-environment climate schemes can be combined with carbon farming certification, particularly with the "Label Bas Carbone" and the National Low Carbon Strategy"
  - The Strategie Nationale de Bas Carbone (2018) includes agroecology, agroforestry and precision agriculture as a means of reducing excessive use of nitrogen fertilisers and conserving soil organic matter
  - The Label Bas Carbone is a carbon offset label launched by the Ministry of Ecological Transition in 2019. Certified projects are held in a registry by the ministry.



Multifunctional Olive Systems combining olive trees with chickpeas.
Author: Anastasia Pantera | © Educational use, non-commercial.

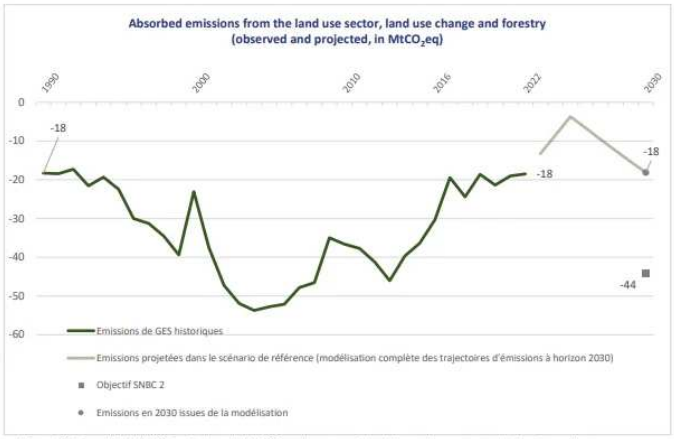


Figure 78: Trends in LULUCF emissions in Mt CO_2eq (source: national greenhouse gas emissions inventory, CITEPA, Secten 2024; DGEC Models)

The forest sector in France is facing great threats from climate change and cannot meet its 2030 GHG targets. Agroforestry has to step up to the plate.

Multifunctional Olive Systems combining olive trees with a mixture of barley and common vetch.
Author: Kostas Mantzanas | © Educational use, non-commercial.

There are currently 11 Label Bas Carbone validated methodologies, including:

- Forestry: improvement-thinning, afforestation, reforestation (where quantities of carbon are evaluated over 30-year periods)
- Agriculture: livestock emission-reduction (CarbonAgri), orchard planting, hedges (low-carbon-lebel), management of inputs (sobac-eco), dairy cattle (eco-methane), field crops.
- Buildings: "renovation" – mainly to improve energy efficiency.
- Transport: support to teleworkers.
- A further 22 Label Bas Carbone methodologies have been submitted, but not yet validated by the Ministry, including for in-parcel agroforestry (proposed by AFAC-Agrofestiers in 2023).

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ResAlliance

Integrated water services and nature-based solutions in the Brenta river watershed

Promoting good governance and innovative financing schemes for biodiversity and water conservation in the Brenta River, Italy.



Figure 1. Brenta river, Italy.
Author: Parco Fiume Brenta | © Educational use, non-commercial.



Figure 2. Brenta river, Italy.
Author: Parco Fiume Brenta | © Educational use, non-commercial.

/// Context ///

Water is essential for life, but the increasing frequency and duration of droughts, combined with the impact of human activities, are putting this resource at risk. It is therefore imperative to act promptly and promote effective adaptation measures to safeguard water resources. In this context, the LIFE Brenta 2030 project carried out a pioneering study in the Middle Brenta Basin with the aim of establishing an innovative Payment for Ecosystem Services (PES) scheme for the protection of biodiversity and water conservation, while addressing the lack of management through the implementation of a system of good governance. The project has succeeded in introducing an innovative financing scheme aimed at adapting the Integrated Water Service (IWS) to climate change and making it more environmentally sustainable by protecting the areas from which the water resource is extracted and where waste is discharged. The innovative financing scheme applies Article 9 of the EU Water Framework Directive (WFD, 2000/60/EC) and the polluter-pays principle, allowing the environmental and resource costs (ERCs) of drinking water consumption to be internalised in the water tariff. The contributions collected through this system will allow the creation of an Environmental Fund for the Brenta River, which will be used to finance measures to protect water resources and mitigate the environmental impact of water consumption through innovative proposals such as Nature-Based Solutions.

/// Solution for a Resilient Future ///

The study area of the LIFE Brenta 2030 project is the Natura 2000 site “Grave e Zone Umide del Brenta”, located in the Brenta river watershed, in the Veneto region, Italy. The site plays a key role in drinking water supply, being one of the most important sources at regional level. However, high water abstraction, anthropogenic impacts, inappropriate recreational uses and a lack of good governance are threatening water quality and conservation, as well as biodiversity. In order to solve these problems, the LIFE Brenta 2030 project has designed an innovative financing mechanism for the water sector with the aim of eliminating, mitigating and compensating the impacts of the Integrated Water Service (IWS): the public service responsible for the activities of captation, adduction and distribution of water for:

- civil use
- sewage treatment and
- wastewater treatment

The innovative financing scheme (Figure 3) provides for the integration of the environmental and resource costs (ERCs) of drinking water consumption into the water tariff, as required by Article 9 of the WFD. Environmental costs are the damage that water use causes to the environment, while resource costs are the costs of lost opportunities that other water users suffer as a result of the water service. By applying the ERC funding scheme, the impacts of drinking water consumption will be addressed to ensure the sustainability of the system in line with the ‘polluter/user pays’ principle of the EU WFD. With the contributions

collected, the LIFE Brenta project will then be able to implement targeted measures to protect water resources and biodiversity.

From these experiments, a standard and replicable methodology was formulated:

1. Creation of a working group of experts from the academic sector and local water authorities to deal with the complexity of the mechanism;
2. Identifying and quantifying the impacts of the IWS to ensure protection of habitats and biodiversity, future water availability, recreational use of the site and land use;
3. Identification of possible measures to eliminate, mitigate or compensate for the environmental impacts of water abstraction (e.g. implementation of NBS or management measures);
4. Identify the areas where the measures should be implemented using a decision support system (DSS);
5. Inclusion of the identified measures in the investment plan of the local drinking water authority. Once approved by the national authority, they will be implemented and their costs covered by the ERC element of the water tariff.

The whole process has been one of political, cultural and technical change, involving all levels of management, from source to user. In this context, the LIFE Brenta 2030 project has ensured the acceptance of this new financial mechanism by both local citizens and stakeholders by activating a participatory process involving all institutional actors in the territory and defining with them a shared management scheme. The scheme foresees a central role for the Drinking Water Board, which later acquired Natura 2000 responsibilities, becoming the local authority for integrated water and biodiversity management.

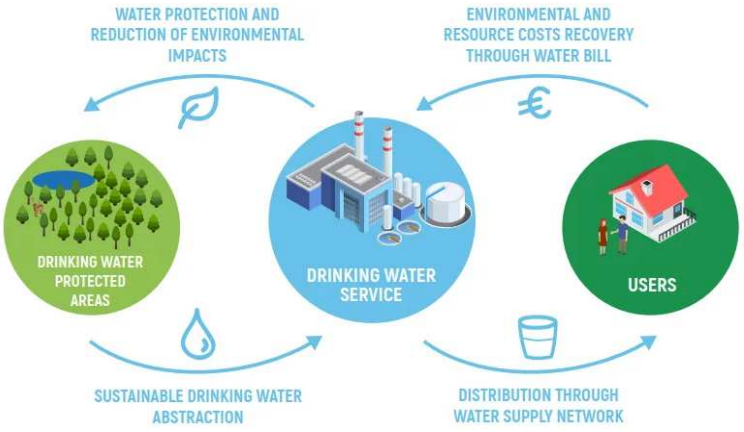


Figure 3. Infographic of the innovative funding mechanism: internalisation of Environmental and Resource Costs in the drinking water service.
Author: Parco Fiume Brenta | © Educational use, non-commercial.



Figure 4. LIFE Brenta 2030 interventions for water and biodiversity conservation.
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/// Always Moving Forward ///

The internalisation of ERCs is an innovative mechanism that could provide a constant and very consistent source of funding for the protection of water resources and associated ecosystems in the future. This case study, applied for the first time in the Italian region, is therefore a pathfinder for other basins interested in preserving water resources. In fact, thanks to the formulation of a standard and replicable methodology, this innovative financial mechanism has the advantage of being replicated in other river basins facing similar challenges. Moreover, looking to the future, it could be interesting to extend the internalisation of ERC to other sectors outside the water sector. For example, this mechanism could be applied to the agricultural or hydropower sectors, where water use is high. The process of internalising environmental costs for the other sectors would require a regulatory regime at the regional level, where the responsibility for setting charges resides. Only by applying the ERC to all the different water uses will it be possible to fully implement the principle of "full cost recovery" outlined in the WFD and to spread the costs of sustainable water management equitably at river basin level.

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Authors: Erica Frassetto; Etifor | Valuing Nature. Giacomo Laghetto; Etifor | Valuing Nature. | **Partners:** ETIFOR – Valuing Nature

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ResAlliance

BioClima: integrating public and private financing for natural capital conservation

BioClima is a blended finance initiative promoted by the Lombardy Region (Italy) to support investment in protected areas for biodiversity conservation and climate change adaptation.



FIgure 1. Invasive alien species degrading important riparian forest ecosystems along the Adda Sud Regional Park | Author: Parco Regionale Adda Sud | © Parco Regionale Adda Sud



Figure 2. Forests affected by a windstorm in the Campo dei Fiori Regional Park. Author: Parco Regionale Campo dei Fiori | © Parco Regionale Campo dei Fiori

/// Context ///

Developing new financial solutions to increase the funding for natural capital conservation is a pressing need for governments and public bodies all around the world.

> **New solutions to bridge the biodiversity finance gap and leverage private capital.**

In response to this challenge, the Lombardy Region and Cariplo Foundation have jointly developed the Biodiversity and Climate (BioClima) initiative within the LIFE integrated project GESTIRE 2020. The BioClima initiative represents an innovative funding instrument integrating public and private financing to invest in the conservation of natural capital. In practice, Lombardy Region provides € 3.5 million funding through grants, supplemented by a Technical Facility assisting the beneficiaries and supporting them in raising an additional € 1.5 million of private co-financing.

By bridging public and private sectors, BioClima maximizes financial support for projects aimed at biodiversity conservation, climate change adaptation, and the enhancement of ecosystem services within protected areas and Natura 2000 sites — the European Union's network of vital nature protection areas — across the region. To ensure transparency, accountability, and the effective use of financial resources, all funded projects need to have their impacts in terms of ecosystem services, e.g. biodiversity conservation and restoration of carbon stock, verified and monitored according to internationally accepted standards, such as those defined by the Forest Stewardship Council® (FSC®).

> **Developing new financial solutions to increase funding for natural capital conservation is a pressing need for governments and public bodies.**

> **BioClima is an innovative and ambitious initiative at European level that could provide valuable lessons for policymakers and practitioners.**

The initiative was launched in 2022 with a first pilot lasting 3 years. Twelve projects have been awarded with funds and technical assistance, supporting the conservation of 16 priority habitats and 22 species within the region.

BioClima is an innovative and ambitious initiative at European level that could provide valuable lessons for policymakers and practitioners aiming to bridge the biodiversity finance gap and leverage private capital. Moreover, this initiative could serve as a model for replication in diverse regions and contexts at European level.

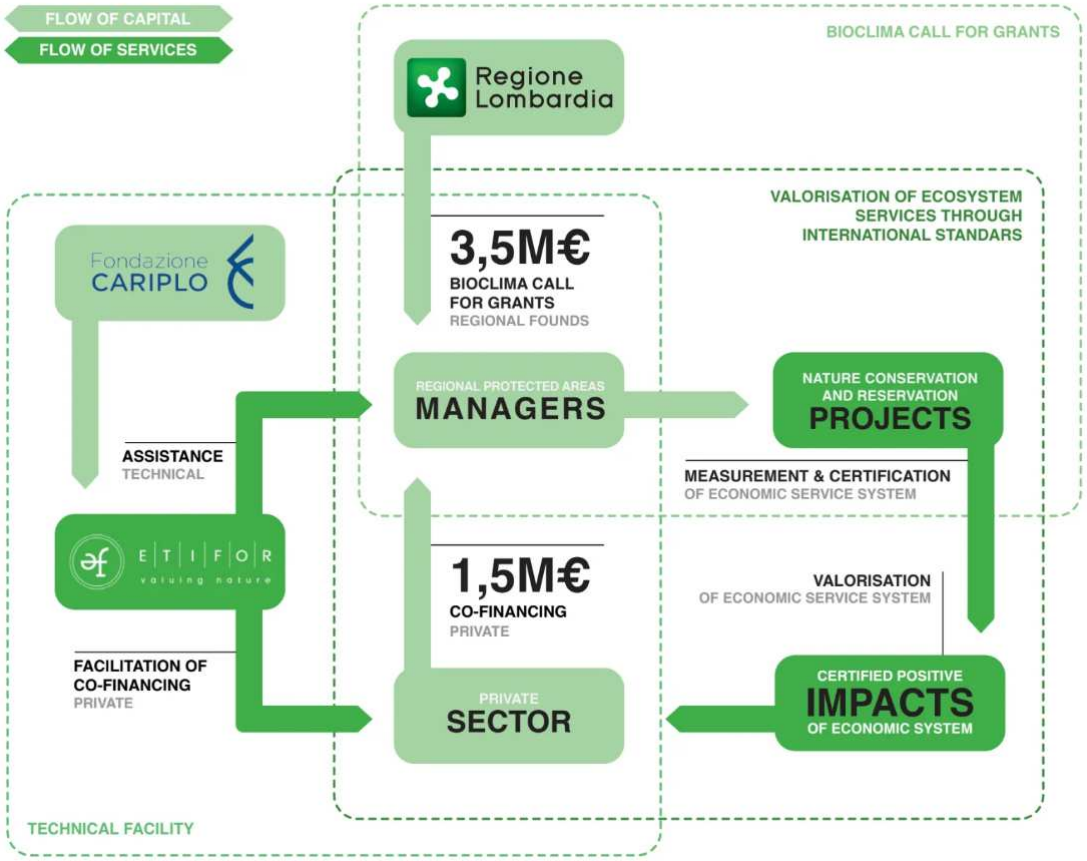


Figure 3. BioClima model flowchart.
Author: ETIFOR – Valuing Nature
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Development, actors involved and blended finance model.

The BioClima initiative was developed as part of the LIFE integrated project "GESTIRE 2020 – Nature Integrated Management to 2020", with the contribution of the LIFE+ financial instrument of the European Commission (www.naturachevale.it), demonstrating the key role of EU grants to enable and catalyze research and innovation. In particular, the action aimed at testing governance pathways geared towards activating innovative financing mechanisms to support ecosystem services.

The BioClima initiative is a public-private partnership: a form of cooperation between public and private entities with the aim of financing services of public interest. In this case, the collaboration aims to finance interventions for biodiversity conservation, climate change adaptation and enhancement of ecosystem services provided by protected areas and Natura 2000 sites.

The BioClima initiative consists of three key components (Figure 3):

- BioClima Call for proposals of Lombardy Region targeting Regional protected areas managers (i.e. managing bodies and public administrations managing protected areas and Natura 2000 sites) to fund biodiversity conservation, climate change adaptation and ecosystem services enhancement projects. More specifically, the eligible interventions include the creation of new natural areas (e.g. forests, permanent grasslands, wetlands) and improvement of existing ones (e.g. by eradicating exotic species, recovering areas damaged by extreme events like windstorms or wildfires, species enrichment), expansion of habitats useful for biodiversity conservation and creation of new green infrastructures for ecological connectivity (e.g. green corridors via buffer stripes) and increasing the provision of ecosystem services and their economic valorization by making habitats and human communities more resilient. For the call, 3.5 million Euro of public regional funds were made available through capital grants. To be eligible to access these resources, applicants are required – besides meeting the technical and administrative requirements – to involve the private sector in the co-financing at least 30% of the projects through activities for the valorization of ecosystem services impacts. Therefore, the target in terms of private co-financing contribution is 1.5 million Euro, thus ensuring a total of 5 million Euro for the call.

The BioClima initiative was developed as part of the LIFE integrated project GESTIRE 2020, demonstrating the key role of EU grants to enable and catalyze research and innovation.



Figure 4. Local citizens involved in community tree planting events.
Author: ETIFOR – Valuing Nature | © ETIFOR – Valuing Nature

- A Technical Facility service, financed by Cariplo Foundation and entrusted to Etifor, granted technical assistance to the beneficiaries in the designing of the project and searching for private sponsors (through the use of the www.wownature.eu platform and other marketing strategies and tools), to raise the private co-financing needed for the project implementation. Therefore, the Technical Facility plays a key-role at the interface among different actors involved in the project proposals and facilitating the identification and engagement of project partners, including co-funding ones.

- Internationally applicable and scientifically recognized standards, e.g. the FSC® Procedure on Ecosystem Services, are used to verify ecosystem services impacts as a tool to ensure scientific monitoring of impacts and overall transparency, accountability, and the effective use of financial resources of the projects. The FSC Procedure on Ecosystem Services provides a framework for FSC-certified forest managers to credibly demonstrate the impact of their activities on the conservation, restoration, or enhancement of ecosystem services through a "theory of change" approach and the implementation of appropriate verification methodologies assessed by independent third-party auditors. It also allows verifying impacts and approving FSC ecosystem services claims that can be used by forest managers to access ecosystem services markets and to sponsors to report credibly their contributions.

The BioClima initiative consists of three key components: a call for grants; a Technical Facility service; and standards for ecosystem services impacts verification and reporting.

/// Always Moving Forward ///

The initiative relies on an innovative blended finance model, which is a system that uses public financing to attract and facilitate private sponsorship, coupling the two sources of funding. In this specific case, the model works on two levels:

- on a regional scale, the Regional public entity (Lombardy Region) provides grant funding, supplementing it with philanthropic funding of private origin (Cariplo Foundation) for implementing a technical assistance service;
- on a local scale, each beneficiary raises private sponsorships from private companies and organizations by generating validated or verified positive (based on the type of intervention and impact) impact claims from the projects.

Therefore, the initiative tests a public-private mechanism with the involvement of private companies and organizations through the economic valorization of the ecosystem services impacts generated by the projects. This mechanism makes it possible to involve the private sector in the natural capital conservation financing challenge, to multiply the available public funds, and to amplify the media and dissemination capacity on the benefits of the projects financed.

BioClima attracted the interest of the 30 regional protected areas managers and resulted in the application



Figure 5. Great egret (Ardea alba), a protected species in the Oglio Nord Regional Park.
Author: Luigi Gibellini | © Luigi Gibellini

Impacts and future developments.

of 18 projects. Of these, 12 were approved (2022), funded and are currently ongoing (2023-2025).

It is estimated that after the implementation phase, the projects will have generated the following results:

- third-party certification for responsible forest management according to the FSC® standard on more than 3,000 hectares of forests and related habitats;
- 12 projects with verified positive impacts on biodiversity conservation and carbon stock conservation or



Figure 6. Reforestation intervention in the Torbiere del Sebino Natural Reserve.
Author: Riserva Naturale delle Torbiere del Sebino | ©Riserva Naturale delle Torbiere del Sebino

regeneration, and 3 projects with verified positive impacts with watershed services, according to the FSC® Procedure on Ecosystem Services;

- forest improvement interventions on more than 300 hectares;
- more than 27 hectares of biodiversity-specific interventions;
- over 66,000 trees planted in reforestation, rows and edges on agricultural lands and ecological enrichment under canopy of degraded forests;
- interventions for the conservation of 16 protected habitats;
- interventions for the conservation of over 22 protected species;
- resources worth € 5.6 million mobilized to finance interventions for biodiversity conservation, climate change mitigation and adaptation, and enhancement of ecosystem services;

• more than 150 people trained on responsible forest management standards and procedures for verifying impacts on ecosystem services;

Resources worth € 5.6 million have been mobilized to finance interventions for biodiversity conservation, climate change adaptation, and enhancement of ecosystem services.

The initiative tests a public-private mechanism with the involvement of private companies and organisations through the economic valorisation of the ecosystem services impacts.

• dissemination and awareness on the topic granted through more than 20 field events open to citizens and businesses and over 100 mentions in the local or national press.

Italy and Europe face challenges in meeting natural capital conservation targets. The EU Nature Restoration Law aims to protect 20% of land and marine territories by 2030 and restore degraded ecosystems by 2050. The associated costs for Italy, are estimated at € 260 million annually. Therefore, collaboration with the private sector is crucial, given the significant economic reliance on nature-related activities and considering that current funding levels cover only a fraction of natural capital conservation needs.

In this framework, the BioClima experience, launched on a pilot basis in 2022 and going to reach completion in 2025, could provide valuable lessons for policymakers and practitioners aiming to bridge the biodiversity finance gap and leverage private capital.

This experience could serve as a model for replication at a regional level and possibly even scaled up to a inter-regional level or replicated in other contexts.



Figure 7. Thinned afforestation in Canneto sull'Oglio.
Author: Consorzio Forestale Padano | © Consorzio Forestale Padano

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Acknowledgment / Contribution

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Public-people partnerships to sustain cork oak Tunisian forests: a new approach to investing in ecosystem restoration and improving local incomes

Shared governance between public authorities and local population in the Ain Drahem forest was carried out to ensure the success of oak reforestation.



The cork oak forests of northern Tunisia are unique ecosystems, rich in cultural and biological diversity and the source of many goods, especially cork.
Author: Boutheina STITI | © Educational use, non-commercial.



Households often depend on grazing for their livelihoods, leading to a lack of forest regeneration and the failure of oak plantations in Ain Drahem.
Author: Boutheina STITI | © Educational use, non-commercial.

/// Context ///

In Tunisia, cork oak direct seeding trials conducted on more than 3,000 hectares between 1988 and 1989 were unsuccessful (Hasnaoui, 1992). Subsequently, plantations conducted between 1995 and 1999 were also unsuccessful. Numerous issues were observed with the surviving plants, including the crawling phenomenon (Stiti et al., 2021a). This phenomenon, resulting in high young tree mortality rates and low tree density stands, is related to the edaphoclimatic conditions found in the regions and to a lack of suitable silviculture and management practices, particularly in the first years when tree establishment is crucial.

> **Landscape rehabilitation is no more successful without programming alternatives to grazing for Tunisian communities.**

In a novel approach, a contractual partnership was established in Tunisia for the first time to facilitate forest restoration. In three pilot sites located in the northwestern region, a participatory approach was employed to facilitate constructive dialogue between local communities and authorities on forest conservation and regeneration. This dialogue ultimately led to the involvement of local communities in the cork oak plantation. This relationship had a significant impact on

> **By involving the local population in planting operations, one can enhance the survival rate of cork oaks under climate stress and build trust in local authorities for a better partnership.**

> **In this pilot experience, forest inhabitants are encouraged to organize themselves into NGOs to facilitate empowerment and seek their own socio-economic benefits.**

local ownership of the restoration work. Local populations were involved in the following activities between November 2016 and August 2018: site preparation, tree fencing, tree planting and summer irrigation. The resulting tree survival rate was estimated at 66%, significantly higher than the 55% observed in plantations carried out by forest services. The local population contribution improved seedling survival and raised awareness, as well as trust, towards forest services. Furthermore, the project has initiated a local development dynamic that benefits the local population.

The implementation of beekeeping activities in the project pilot areas has led to the emergence of new sources of income. Following training in beekeeping and the acquisition of beehives through the concession programme, the local population has committed, via local representatives (NGOs), to monitor the plantations and using the flora sustainably.

At the end of the project, the satisfaction of the local population and the promising results observed led to the decision to replicate this experiment in other degraded areas. To optimise the regeneration of the cork oak forest, the project has modernised the nearest nursery and created an acorn storage and processing centre in Ain Draham.



Active community involvement increases survival rate of cork oaks and reduces conflict with forestry services in Ain Drahem district.
Author: Boutheina Stiti | © Educational use, non-commercial.



Dialogue with local communities, including a gender approach, could be the solution to rehabilitate and develop the forest in northwest Tunisia.
Author: Boutheina Stiti | © Educational use, non-commercial.

/// Solution for a Resilient Future ///

The management of cork oak forests over the last three centuries has led to the decline and deforestation of Mediterranean cork oak forests. Long dry seasons (climate change), forest fires and overgrazing are considered to be the main causes of these problems, along with management practices (Stiti et al., 2021).

A recent study on the economic value of cork oak forest services (Khalfaoui et al., 2020) demonstrated that grazing provided a significant economic benefit of 0.16 M€/year in north-western Tunisia in 2016. This value ranged from 33% to 48% of the total economic value (TEV), depending on the stand density. It is noteworthy that Tunisian cork oak forests are public property, yet the local population has free access to them. The TEV was actually shared between local users (58%) and the government (42%) (Daly-Hassen et al., 2009).

A rural household owns on average 1.8 cattle, 6.3 sheep and 4.5 goats, based on subsistence production and grazing. The average grazing time is five hours per day in the forest and two hours in the scrub, with acorn collection and stocking occurring during low production periods (Khalfaoui et al., 2017). This behaviour is often justified by the high prices of raw materials used in animal feed, the majority of which are imported. Grazing and other agroforestry activities are carried out alternately by men and women, and sometimes by children. Given the difficulties inherent in natural regeneration and direct sowing, the plantation has been identified as the optimal method for the rehabilitation of cork oak forests, particularly in light of the advancements in seedling production techniques.

In Tunisia, cork oak forests are publicly owned and managed by the Forest Administration (FA), which oversees their usage by the local population without involvement in management and conservation issues. This arrangement has led to a conflictual situation. Moreover, the plantations, which have been carried out by FA agents or given to companies, have yielded disappointing results. This study aimed to test, for the first time in Tunisia, the feasibility and effectiveness of co-executing the rehabilitation operation. In the context of a project funded by the Korea International Cooperation Agency (KOICA), the local population residing in three selected sites in Northwestern Tunisia were assisted in establishing agricultural development groups. A contract was signed in 2016 with their representatives. In collaboration with FA agents and researchers, they contribute as stakeholders to the Business Continuity Plan (BCP). The average cost of the plantation was estimated at €1,388 per hectare. Indeed, local population contributed in all the activities from the fencing by 46.4% of the costs to the strip clearing (100% of the charge) and planting (68.5%). Guarding (66.1%) and summer irrigation (100%) were added to ensure plantation success. Although the relative high cost of this experience, the local population contribution rise awareness and improved seedlings survival. After two years, the results showed an average of survival rate of cork oaks estimated at 66% which is considered high compared to similar plantations fulfilled before.

Shared governance of planting activities among all forest stakeholders: jointly responsible and all beneficiaries.

In order to offset the impact of the fenced area following planting and to alleviate pressure on the forest, it may be advisable to promote alternative activities that will enhance local incomes.

This case study has revealed that dialogue with the local population has highlighted common areas of concern. Furthermore, it demonstrates that a shared vision of management strategy can be achieved. The strategy entails monitoring the plantation sites and prohibiting grazing by local and foreign populations.
Additionally, the strategy aims to enhance the income of families engaged in livestock farming and to facilitate their diversification of agricultural activities. Two potential avenues for development in this region are beekeeping and family gardens. It is also recommended that non-timber forest products be encouraged, with particular attention to the needs of women.

Actually, at the national level, the strategy for the sustainable development of forests and rangelands in

Should the concession with the community be unfeasible and lacking in clear objectives, the rehabilitation process could prove to be an expensive failure.



The local community in the Ain Drahem forests shares in the success of the plantations and is involved in all operations.
Author: Ali Khorchani | © Educational use, non-commercial.

Tunisia 2015 – 2024 is based on four strategic axes:

- Adaptation of the institutional and legal framework and capacity building.
- Optimizing the contribution of the forestry and pastoral sector to rural and national socio-economic development.
- Maintain and improve the environmental services (carbon sequestration, erosion tracking, biodiversity, etc.) and ecosystemic values provided by the sector's resources.
- Strengthening and improving the capital of forest and pastoral resources.

Aim: to enhance knowledge and monitoring through workshops and technical assistance, thereby improving forest resources management.

/// Always Moving Forward ///

The cork oak (Quercus suber L.) occupies a key position among Mediterranean forest species due to its high ecological, socio-economic and landscape value. Its bark (cork) is a highly valuable natural resource used in many ways, and its fruits (acorns) are important in animal feed due to their biochemical and energetic properties. Cork oak forests also support recreational and tourist activities for both local and foreign visitors (Mechergui et al., 2023). Cork oak is one of the most westerly sclerophyllous oaks in the Mediterranean. It is found in large areas of both the southern (Morocco, Algeria, Tunisia) and northern (Italy, France, Spain and Portugal) Mediterranean, covering a total area of approximately 2,123,000 hectares, 67% of which is in Europe and 33% in Africa (APCOR, 2020).

The recovery of the cork oak forests in Tunisia is not an easy task, especially in the context of climate change. Indeed, the resilience of new stands depends on biotic and abiotic factors. Successful planting requires the use of high quality seedlings, fencing for at least 5 years, good site preparation and maintenance of the plants by controlling vegetative competition and browsing by herbivores. Besides, during the two first years watering is important, especially if rainfall is rare or badly distributed. Moreover, local population should be involved in the operation of planting otherwise the conflict of interest due to grazing activity could destroy the planted sites. However, as stakeholders, communities should benefit from the concession. To this end, the project implemented activities based on compensation and dialogue. Several meetings bringing together all the project partners, in particular foresters from the Ain Drahem district, managers from the Jendouba agricultural development administration and the indigenous populations of the 3 sites. In addition, INRGREF and KOICA researchers acted as project coordinators, mediating between the partners and evaluating the experience. The result of the dialogue was an agreement between the authorities and the representatives of each site, setting out the share of tasks to be carried out by each partner. After the formation of the three Agricultural Development Groups (GDA) and the election of the members of its management committees, an action plan for project activities involving plantations and beekeeping was drawn up.

Key to forest recovery is strengthening co-management of natural resources and applying adapted silviculture.



Successful cork oak plantations require good quality seedlings, fencing, summer irrigation and seedling monitoring.
Author: Boutheina Stiti | © Educational use, non-commercial.

To support joint-management of forest resources, certain criteria should be met:

Enhance the institutional and legal framework for forest resource management, including land rights and access to land by by revising the forestry code.

Capacity building for forest managers in communication techniques with local communities to facilitate dialogue.

Capacity building for forest managers in sustainable resource management.



The gender aspect: This is the first time that women in Ain Drahem have taken part in the planting and bee-keeping activities.
Author: Boutheina Stiti | © Educational use, non-commercial.

3 rural development NGOs have been created. They have become autonomous . Thanks to these NGOs, other donors have financed other projects in non-timber forest products.

This project has implemented various activities and introduced new approaches to rehabilitating the cork oak forest in Tunisia.

Limit the decentralization of decision-making in forest management.

Restructure the joint regional development committees and legalize regular meetings between the authorities dealing with agriculture and forestry on the one hand and representatives of local communities on the other.

Promoting social organization in NGO.

Development of agro-silvo-pastoral value chains to improve the income of housholders.



Beekeeping: 19 men and 17 women were trained and selected as beneficiaries through a local NGO based in the Ain Drahem area. The project provided 500 beehives.
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Type of Solution: Governance Sector: Agriculture, Agroforestry, Forestry

Good practice(s): Water management, Soil management, Management alternatives, Ecosystems services, Community engagement

Integrated landscape approaches to reconcile competing land uses

A set of principles to support the implementation of integrated landscape approaches that emphasize adaptive management, stakeholder involvement, and multiple objectives.



Agroforestry landscape in Chittagong Hill Tracts, eastern Bangladesh
Author: Terry Sunderland | © Terry Sunderland



Smallholder oil palm landscape in SW Cameroon.
Author: Terry Sunderland | © Terry Sunderland

/// Context ///

Meeting the multiple demands of a growing global population with a limited amount of land, water and natural resources, while combating climate change, biodiversity loss and ecosystem degradation require integrated approaches that reconcile multiple and conflicting land-use claims within complex, dynamic and multifunctional landscapes. Based on published literature and a consensus-building process validated by practitioners, ten principles were identified to support the implementation of landscape approaches – integrated approaches to improve landscape management in areas where agriculture, forest, mining, and other productive land uses compete with environmental, climate, and biodiversity goals. These principles emphasize adaptive management, stakeholder involvement, and multiple objectives. They illustrate how conservation and development can be reconciled at landscape scale where many issues intersect and unfold. These principles are: (i) continual learning and adaptive management; (ii) common concern entry point; (iii) multiple scales; (iv) multifunctionality; (v) multiple stakeholders; (vi) negotiated and transparent change logic; (vii) clarification of rights and responsibilities; (viii) participatory and user-friendly monitoring; (ix) resilience; (x) strengthened stakeholder capacity. The LandLabs could be a privileged channel through which these principles could be applied, tested, and adapted to specific Mediterranean landscapes.

/// Solution for a Resilient Future ///

Sectoral approaches are likely to create trade-offs across development objectives or over space or time. Integrated approaches are needed to reconcile multiple and often conflicting development objectives and land-use claims within complex, dynamic and multifunctional landscapes. Such integrated approaches need to be adapted to the local biophysical, socio-economic, cultural and institutional context, and to the common objectives pursued. Ten principles were identified to guide the decision-making process in landscape contexts. These principles promote more inclusive landscape governance that help identify common concerns, improve coherence across scales, and negotiate trade-offs. They emphasize the need for integrated and people-centered landscape approaches to reconcile conservation and development, address conflicting interests, maximize synergies and minimise trade-offs across development objectives, and across sectors, actors and scales:

1. *Continual learning and adaptive management* are critical to deal with non-linear dynamics, uncertainties and surprise, in continuously changing landscapes.

2. *Common concern entry point.* As stakeholders have different interests, values and objectives, identifying immediate ways forwards or easy-to-reach intermediate targets to address topics of common concern can help building trust and consensus, thus facilitating collective action.

3. *Multiple scales.* Management outcomes are influenced by processes and actors operating at multiple spatial and temporal scales. A better understanding of cross-scale interactions and a better coordination across scales is therefore critical in any landscape approach.

4. Multifunctionality. Acknowledging the multifunctionality of landscapes is the first step to manage synergies and trade-offs among competing land uses and reconcile the various needs, preferences and aspirations of all the stakeholders involved or affected.

5. Multiple stakeholders. Without inclusive, meaningful and equitable participation of all stakeholders, the decision-making process may lead to sub-optimal or unfair outcomes or exacerbate conflicts and power asymmetries.

6. Negotiated and transparent change logic. Trust among stakeholders is key for good management, collective action, conflict prevention and resolution. Trust cannot appear without transparency, negotiation and good governance.

7. Clarification of rights and responsibilities. A clear and widely accepted repartition of rights, roles and responsibilities, and access to a fair justice system are required to prevent and solve conflicts. Facilitation and negotiation processes are replacing the traditional command-and-control approach.

8. Participatory and user-friendly monitoring is key to integrate different forms of knowledge, and enable shared learning, knowledge co-generation and adaptive management.

9. Resilience, which enables a system to absorb, avoid or deflect threats and to recover after a disturbance, is fundamental to sustain ecosystem processes, services and benefits over time and ensure that a system can persist under and respond to changes.

10. Strengthened stakeholder capacity. Meaningful participation in the decision requires improved skills and capacities, as well as effective representation and competent institutions.



Upland and paddy rice being grown on Cat Ba Island, Vietnam
Author: Terry Sunderland | © Terry Sunderland



Paddy fields on the slopes of Gunung Halimun, West Java, Indonesia
Author: Terry Sunderland | © Terry Sunderland

/// Always Moving Forward ///

The lack of consensus on the definition and basic rules of integrated landscape approaches may have hindered their implementation on the ground and evaluation of their effectiveness. The abovementioned principles could help address this implementation gap. This will require broad stakeholder engagement, through continuous or at least regular negotiations, within polycentric and multi-level governance mechanisms that facilitate the emergence of new actor constellations and enhance coordination across sectors, actors and scales. Furthermore, developing an understanding of the historical context, contemporary power dynamics, and current constraints to access and engage in decision-making spaces for marginalized groups will greatly benefit application of landscape approaches.

The ten abovementioned principles align quite well with resilience thinking as emerging from the literature, even if they focus more on the social and governance dimensions than on ecological ones. The LandLabs are a promising channel through which these principles could be applied, tested and adapted to specific Mediterranean landscapes.

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Model Forest: balancing local needs with sustainable landscape management

The Ifrane Model Forest: a participatory governance and co-management approach to preserve the Middle Atlas forest landscape.



Ifrane National Park. High mountain pasture (foreground), natural stands of Cedrus atalantica (background). | Author: https://wildsafariguide.com/listing/ifrane-national-park
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Atlas cedar dieback observed in forests from Middle Atlas Source.
Author: Forests 2016, 7, 172; doi:10.3390/f7080172 | © Educational use, non-commercial.

/// Context ///

The Ifrane National Park is part of the Moroccan Middle Atlas mountain range. The territory is distinguished by a mountainous landscape, with an altitude gradient ranging from low hills to high summits with the highest point at 2,409 m. It features diverse ecosystems including extensive cedar forests, oak woodlands and alpine meadows.

Cedar forests are threatened by a combination of two phenomena: cedar dieback and resource degradation. Resource degradation is essentially due to overgrazing and the excessive harvesting of forage and firewood by an ever-growing population relying on a subsistence economy. Overgrazing cause soil degradation and reduced water availability. Cedar dieback, which is closely related to water stress, has worsened due to ongoing droughts and may be further aggravated by climate change.

To address those challenges, a participatory governance and co-management approach has been adopted. This approach was designed to transform the wider area of the Middle Atlas into a Model Forest system – with the national park at its core – empowering local communities, forest authorities and other stakeholders to carry out initiatives focused on sustainable development, forest conservation and improving quality of life. This has included activities such as: i) working with silvopastoral management associations, ii) natural regeneration of Atlas cedar stands, iii) improving shepherds' grazing capacity, iv) restoring maritime pine burnt areas, and v) improving local livelihoods.

/// Solution for a Resilient Future ///

A Model Forest is best understood as a process for bringing a diverse partnership of individuals and groups together to realize a common vision of sustainable development in a large landscape. Based on the principles and characteristics of Model Forests, the Ifrane Model Forest's strategic directions focus on adaptable landscape and ecosystem management that combines environmental, social and economic needs of local communities with long-term sustainability of large landscapes. All activities to mitigate threats, address environmental, social and economic challenges employed a participatory governance and co-management approach. Example of such activities include:

- Collaboration with Silvopastoral Management Associations (SMAs). Comprising 11 recognized associations, SMAs are operating under a partnership with the High Commission for Water, Forestry and desertification. SMAs recognized the unsustainability of traditional grazing cycles which resulted in increased pressure on pastoral and forest lands. Shepherds have acknowledged these challenges and expressed needs for solutions, including rotational grazing practices to improve grazing areas and enhance incomes.
- Natural regeneration of Atlas cedar. A cedar stand adjacent to a grazing area was fenced to prevent grazing. Few years after grazing stopped, natural regeneration began mainly in open areas under cedar canopy. This initiative demonstrated that in areas where cedar occurs naturally, the cessation of grazing can promote and lead to natural regeneration. Natural regeneration significantly reduces CO2 emissions associated with nursery plant production, soil preparation and irrigation. Afforestation should be reserved for situations where natural regeneration is challenging or where long-term cessation of grazing is not technically or socially viable.

- Enhancing grazing capacity. Measures such as planting diverse native herbaceous plant species, installing watering troughs on strategic locations and creating a 10 kilometer row of Atlas cedars were carried out to encourage greater rotation of grazing animals and to enhance the overall grazing capacity in the region.
- Restoring maritime pine burnt area. A fire in 2022 damaged a 1,000 hectares of maritime pine, causing a sharp decline in soil fertility and altered the species composition of the site. Artificial replanting of maritime pine with improved soil fertility methods (bare root seedlings pre-soaked in a mixture of mature forest soil and water) along with fire prevention measures were carried out to support natural ecosystem recovery.
- Enhancing Local Livelihoods. SMAs have initiated small-scale lavender and saffron plantations to boost biodiversity and incomes of local communities. Initial planting of lavender seedlings faced difficulties adjusting from nursery to field conditions. Rescue irrigation is being used on lavender seedlings to aid root system establishment and vegetative growth. Both plantations are showing promising results, with yield of saffron spice reaching 4 kg/ha yield after 3 years of cultivation.



Recovery of vegetation after protection (in the foreground) compared to the degraded land (background), Middle Atlas.
Author: S. El Khiyari | © Educational use, non-commercial.



Burnt area restoration in the Middle Atlas. Replanting maritime pine (Pinus pinaster).
Author: https://www.medmodelforest.net/en | © Educational use, non-commercial.

/// Always Moving Forward ///

While significant progress has been made in integrating social needs and ecological restoration in the Middle Atlas forest landscape, several strategic steps are needed to consolidate gains and ensure the long-term success and sustainability of restoration activities, with a focus on continued stakeholder collaboration, monitoring, evaluation, adaptive management and scaling up of successful models.

In particular, strengthening partnerships with SMAs and local communities is critical to scaling up rotational grazing practices and integrating them into broader land management strategies. Increasing natural regeneration efforts for Atlas cedar and other native species would further enhance carbon sequestration and ecosystem resilience. Increased investment in increasing grazing capacity and improving fire prevention measures will further support sustainable land use. In addition, scaling up successful small-scale projects such as lavender and saffron plantations can provide a model for improving livelihoods.

By promoting adaptive management strategies and fostering the resilience of local communities, the Ifrane Model Forest will remain a living laboratory for sustainable development and a model for similar initiatives in the Mediterranean region.

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Rediscovering the bio-economy potential of the wool sector in the Mediterranean

Harnessing the Potential of Silvopastoral Systems to Create New Economic and Environmental Value.



Silvopastoral system with Walnuts – Bosques Naturales, Spain.
Author: Monica Pelliccia | © Educational use, non-commercial.



Nieves Fernández Vidueira (Spanish farmer) among her 400 sheep grazing in the agroforestry system.
Author: Monica Pelliccia | © Educational use, non-commercial.

/// Context ///

The Mediterranean region has a long history of sheep farming, with wool production playing a vital role in the local economy and cultural identity. However, socio-economic considerations accelerate rural exodus in the region, leading to a massive decline in the number of shepherds and sheep farmers. Moreover, the impacts of climate change, including increased temperatures, droughts, and extreme weather events, are posing significant challenges to traditional sheep farming practices in the region.

In this context, the integration of sheep grazing within Mediterranean agroforestry systems, known as silvopastoral systems, is re-emerging as a promising approach to revitalising the sheep farming sector while also enhancing climate resilience and delivering environmental benefits.

Further valorising wool as a key product in the area of bio-economy innovation may bring additional economic benefits to the region. Yet, stringent regulatory measures and unfair competition pose an existential threat to wool production in Europe. This factsheet is primarily addressed to policymakers, highlighting the numerous advantages of silvopastoralism and wool production – while underscoring the urgent need for a more favourable legislative context for locally-produced wool.

Drawing inspiration from the six indicators of sustainable development listed in the EU Taxonomy Regulation, as illustrated in the 'Brno Agroforestry Declaration', we highlight how the untapped bioeconomy potential of wool can be a game changer for the Mediterranean region.

/// Solution for a Resilient Future ///

The wider integration of sheep grazing within Mediterranean agroforestry systems, as well as the valorisation of wool derived from such systems offer a range of benefits in the following areas.

Climate change mitigation

The footprint of meat and wool production may be reduced. It is shown that the Mediterranean Dehesa like systems, where transhumance is practiced, allow to reduce feed inputs and GHG emissions, while extensive grazing supports carbon sinks. Such lamb meat has a footprint of up to 30% less than sedentary lamb, data which could support similar findings when assessing the footprint of wool from extensive farming systems.

Sheep grazing adaptation to climate change

Better nutrition, especially during periods of drought, helps maintain the health and productivity of the flock, even in the face of a changing climate. Adequate nutrition (e.g. protein intake) is crucial for maintaining wool growth rate and fibre diameter in breeding ewes and young sheep. Research done in Australia indicates that supplementing the diet of sheep with Fabaceae shrubs may increase the wool yield of supplemented Merino wethers with production reaching up to 0.18 mg wool/cm²/day. Additionally, tree-based landscape features provide better animal welfare conditions, in line with sheep's natural behaviour. Silvopastoral systems can provide shade and shelter for sheep, reducing environmental stress. This improves their welfare and productivity, while also allowing livestock to spend longer periods outdoors.

Soil, water and atmospheric pollution

Tree fodder may reduce the costs related to veterinary products. Recent evidence highlights the role of willow fodder in reducing cobalt deficiency in lambs, without the need for additional treatment such as boluses (Innovative Farmers). Tree-fodder also play a role as anthelmintic. These benefits contribute to reducing the use of agropharmaceuticals – which may be pollutants derived from livestock farming. Another key advantage of using wool – as opposed to synthetic fibres – is that it does not generate microplastics. This is of key importance in the region, as more than half of its population lives in coastal regions.

Protection of biodiversity and ecosystems

In the area of biodiversity conservation, it is worth noting the role of silvopastoral systems in supporting a greater diversity of plant and animal species compared to

conventional monoculture pastures. This can help preserve the rich biodiversity of the Mediterranean region, which is under threat from various land use changes.

Circular economy

While wool is recyclable, the scarcity or the complete lack of scouring plants across Europe makes exporting raw/used wool the preferred option. From Formula 1 equipement or NASA t-shirts or 3D printed furniture, the possibilities to innovate are endless!

Rural socio-economics

The integration of sheep grazing within Mediterranean agroforestry systems offers a range of benefits that can create new economic opportunities while also addressing climate-related challenges. The diverse and nutrient-rich forage available in these systems can enhance the quality and characteristics of wool produced by the sheep. This includes improvements in fibre strength, softness, and natural colour variations. As a result, the wool can achieve a higher market value, particularly when traditional textile products are generated.



The project DEFI-Laine worked on promoting local wool supply chains, where all the processing stages are local.
Author: Interreg project: DEFI-Laine | © Educational use, non-commercial.



Weavers in Ulassai.
Author: Wikipedia | © Educational use, non-commercial.

/// Always Moving Forward ///

To drive the widespread adoption of climate-smart wool production through Mediterranean agroforestry, a collaborative effort involving researchers, policymakers, and industry stakeholders is necessary. This may include:

- Addressing regulatory barriers (e.g. the ban on forest grazing) to facilitate the integration of sheep grazing across landscapes. Further addressing uncertainties related to wool safety (e.g. uncertainties about the European Union legislation on animal by-products) is also key to unlock the innovation potential of the sector.
- Developing decision support tools and guidelines to help farmers and landowners design and manage optimal silvopastoral systems for their local conditions and production goals.
- Establishing or relying on existing certification / traceability schemes to ensure the authenticity and provenance of climate-smart wool products (see IWTO.org).
- Developing decision support tools and guidelines to help farmers and landowners design and manage optimal silvopastoral systems for their local conditions and production goals (the crossborder Interreg project 'MARLAINE' involves key actors in the wool supply chain in Sardinia, Tuscany, Corsica and Provence-Alpes-Côte d'Azur).
- Exploring innovative business models and marketing strategies to promote the unique qualities and sustainability credentials of wool derived from agroforestry-raised sheep. Cooperatives such as 'Comercial Ovinos SCL' in Spain contribute to better valorising wool from small producers in Extremadura and Andalucia.

Further information

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- Read more about the 'MARLAINE' Interreg project: https://interreg-marittimo.eu/fr/-/marlaine-evento-di-lancio-del-progetto-europeo (Accessed 29 August 2024) (In French)

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