Transition

Innovative resilient farming systems in Mediterranean environments

Shaping the future of agroforestry and mixed farming in the Mediterranean

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1. Introduction

The Transition project in brief

The Transition project (2021-2024) aims to pave the way for a Transition towards resilient agriculture in the Mediterranean, maximizing the net positive impact on the environment, while increasing the economic and environmental resilience of agroecosystems. The Transition project analyzes the most relevant innovative solutions in resilient agroforestry and mixed farming systems for the Mediterranean basin. The project focuses on 5 regions in the Mediterranean basin, located in 5 different countries: Algeria, Egypt, France, Italy and Spain.

A major issue covered by the project is the analysis of the policy and regulatory framework in each participating area with a holistic perspective. In this process we achieved the collaboration of a total of 138 stakeholders from all the agriculture, livestock and forestry value chains in all the participating countries. We used two methods: i) semi-structured interviews, ii) semi-structured meetings.

Figure 1. Map of the study regions (marked in green) in the TRANSITION project

The Roadmap

The aim of this document is to summarize the importance of agroforestry and mixed farming systems as eco-intensification options for the development of sustainable agriculture adapted to climate change in the Mediterranean context. This document also offer steps for policymakers to facilitate decision-making by providing evidence-based tools. To support its discourse, this document is drawing on the results obtained from the technical and policy activities of Transition project.

Agroforestry and mixed farming systems in the Mediterranean basin

To cope with the effects of global change on Mediterranean agro-ecosystems (i.e., water scarcity, drought, soil drying or higher intensity of climatic hazards) and to ensure its long-term viability, the agricultural sector requires a significant shift from conventional farming towards sustainable systems and approaches, including agroforestry and mixed farming. This transition must consider the economic, environmental and social resilience of rural communities.

<u>Agroforestry and mixed farming in brief</u>

The European Agroforestry Federation (EURAF) defines **agroforestry** as "the integration of woody vegetation, crops and/or livestock on the same area of land. Trees can be inside parcels or on the boundaries (hedges). Agroforestry can be applied to all agricultural systems. Agroforestry systems are obtained by planting trees on agricultural land or introducing agriculture in existing woodland/orchards"[1] [2].

The Food and Agriculture Organization of the United Nations (FAO) defines **mixed farming** systems as those in which "producers have some combination of perennial and annual crops, livestock, and/or fisheries"[3]. This agricultural model aims to maximize the diversity of the production systems, emphasize soil fertility conservation and management and optimize the use of energy and the locally available resources.

Agroforestry and mixed farming cover a wide variety of systems adapted to the local environments, resources and cultures. Some farming systems could fall within the definition of both agroforestry and mixed farming (e.g., fruit trees with crops). Conversely, some systems may have a temporary in nature (e.g., young tree plantations are cultivated in rows and then cropping is discontinued as the trees grow larger).

This document focuses on specific types of agroforestry and mixed farming systems, such as agrosilvopastoral, silvoarable, mixed farming and mixed horticulture. The arrangement of the different components (trees, crops and/or livestock) in the field is adapted to the local orography, but they mainly consider alley cropping, hedgerows, or strips.

Alley cropping is an agroforestry method that involves combining rows of trees and/or shrubs with crops (e.g., olive trees and cereal in Italy)

Hedgerow model involves the implementation and management of sideline hedges of woody vegetation (e.g., bocage in France)

Mixed horticultural farming (e.g., combination of multiple crops and trees in France and Egypt)

Silvopastoral (e.g., livestock and forest grazing in France and Spain)

Hedgewrows (e.g., fruit trees in Spain)

Combination of hedgerows, with field margins and riparian vegetations (e.g., cereal diversity in France)

Agrosilvopastoral (e.g.,olive trees, retama and livestock in Algeria)

Jatropha and tomatoes (Egypt)

2. Agroforestry and mixed farming are agricultural systems widely recognized for their agronomic and environmental benefits

Agroforestry and mixed farming systems have different added values for farming communities. Their benefits touch all aspects of farming, from the environmental to the socio-economic.

Agroforestry and mixed farming systems are widely recognized for their multiple benefits, including increased productivity, socio-economic stability and environmental gains. Integrating trees, crops and/or livestock in the same landscape promotes higher yields, biodiversity and resilience to climate variability. This diversification not only ensures sustainable agricultural practices, but also strengthens rural economies. In addition, these systems have shown significant improvements in soil health, water management and carbon sequestration[4]; positioning them as key strategies for sustainable agriculture and climate change mitigation.

Developing agroforestry systems is identified as priority for the Food and Agriculture Organization (FAO) and Union For the Mediterranean (UFM)

The FAO has identified the development of agroforestry as a priority for the near future. In July 2024, the FAO published its "Forestry Roadmap: From Vision to Action 2024-2031". In this roadmap, the FAO has identified the development of agroforestry as its priority action number 7: "Support countries to increase the productivity and sustainable production of forestry and agroforestry systems and create value-added and income opportunities, including for small-scale producers and indigenous peoples".

The Mediterranean Experts on Climate and Environmental Change (MedECC) published the first Mediterranean Assessment Report in November 2020. The report assesses the best available scientific knowledge on climate and environmental change and associated risks in the Mediterranean Basin in order to make it accessible to policy makers, stakeholders and citizens. Agroforestry is proposed as one of the successful adaptation strategies to climate change. Furthermore, agroforestry would reduce water scarcity in the Mediterranean by increasing water-holding capacity and improving yields during periods of water stress [5].

There is a scientific and technical body of evidence on the multiple benefits produced by agroforestry and mixed farming

Scientific research has demonstrated the significant environmental and economic benefits of agroforestry and mixed farming systems. These systems contribute to climate change mitigation [6] , reduce soil erosion, improve soil health[7], increase soil organic matter, soil carbon storage[8] and water retention capacity[9] all while protecting biodiversity[10] (Figure 2).

Economically, agroforestry and mixed farming systems diversify and increase land productivity [11] , leading to higher yields and profitability, when compared to monoculture[12]. Diversified production also provides multiple sources of income, reducing vulnerability to market fluctuations. Furthermore, environmental benefits of agroforestry and mixed farming systems allow farmers to reduce input costs, while maintaining or increasing productivity, making them a resilient and efficient farming strategy.
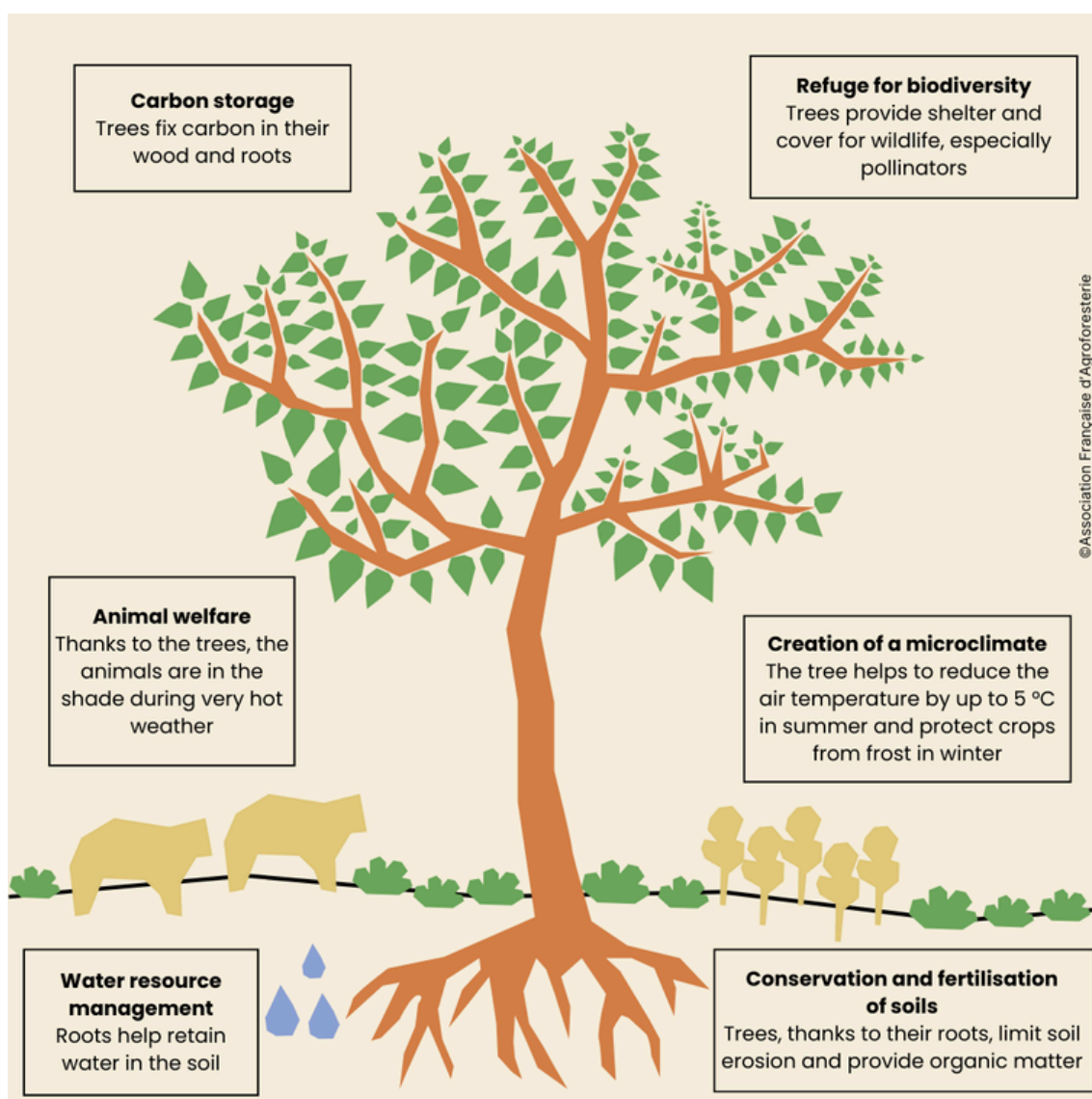

Figure 2. Diagram showing the benefits of agroforestry

The Transition project field experiment are based on traditional practices that already exist around the Mediterranean basin. For example, an agroforestry system (olive trees and winter cereals) in the northern Mediterranean (Italy) and a mixed farming system (jatropha and vegetable crops) in the southern Mediterranean (Egypt). Both have managed field trials of agroforestry and mixed farming over two cropping seasons.

The olive trees and winter cereals agroforestry system was tested over two cropping seasons on an existing 4-year-old olive grove, with trees spaced 5.5 m between rows and 5 m within rows (Figure 3) located at a mountainous site (970m a.s.l.) in Sicily, Italy. The tree rows were aligned along the East-West axis. The trial evaluated three winter cereals, namely durum wheat (*Triticum durum*), common wheat (*T. estivum*), and rye (*Secale cereale*).

Figure 3. Olive trees with tilled field for cereal sowing in Spain

The agroforestry systems achieved higher combined yield (grain and olive yield) in comparison with the same extension of land under the monocropping systems. The combined productivity has been expressed as Land Equivalent Ratio (LER). LER is defined by FAO as the ratio of the area under sole cropping to the area under intercropping, needed to give equal amounts of yield at the same management level . Values of LER higher than 1 signal a higher combined yield than the monocropping system.

Although the yields in the agroforestry system were lower than in the monocropping (between 28% and 59% of reduction for the cereal and between 8% and 18% of reduction for the olive trees), the LER of the whole system varied between 1.2 and 1.6 for all the cereals. It has been shown that in only two years of implementing a new system, there are concrete and positive results in terms of productivity.

The mixed farming plot showed the benefits of combining jatropha trees with tomatoes and potatoes over two seasons. In the first season (May 2023), a split-plot design with three replicates was used. Tomato plants (variety 0186) were grown under the 8-year-old Jatropha trees (*Jatropha curcas*, Mexican non-toxic species) in 32 plots, each measuring 84m². Each plot had an average of 10 Jatropha trees along the center line, with 90 tomato seedlings planted on either side (45 seedlings on each side), for a total of 2930 tomato seedlings, and 320 Jatropha trees across the site. In the second season (February 2024), potatoes (Diamond variety) replaced the tomatoes as both crops are heavily nutrient-demanding and sensitive to climatic conditions; using the same layout and pre-soil management. A total of 6400 tuber were planted (200 per each side) of the Jatropha tree row (100 on each side). Soil organic matter content increased from 0.5% to 2.6% by the end of the second season in 2024. This would directly contribute to a significant increase in crop yields (25% increase compared to traditional farming methods).

One of the most notable results was the resilience of the system to climate variability. In the first season, the tomato crop showed the ability to produce well despite experiencing extreme weather conditions. Temperatures rose an average of 1-8°C above the optimal levels of tomato production, a level that caused significant losses in surrounding tomato fields. This finding is consistent with reports from Egyptian Agri News of widespread crop losses, including tomatoes, attributed to extreme temperature increases. However, the system needs further experimental validation to assess its resilience over time. From an economic perspective, the experimental system showed an average 30% reduction in input costs under similar soil and climatic conditions in Egypt. Tomatoes reached a yield of 79 tons per hectare with LER equal to 1.5, and potatoes produced 31.2 tons per hectare, with LER 1.7.

Figure 4. Experimental potatoe production combined with jatropha in Egypt

Further information regarding the on-farm research can be found in the report of Deliverable 2.4 of the Transition project.

3. Despite scientific recognition, agroforestry and mixed farming need to be promoted by legislation and within the farming community

Over the last two decades, agroforestry and mixed farming have gradually been integrated into national and international agricultural policies. Effective promotion through policies and initiatives is crucial for wider adoption.

Within the European Union, agroforestry and mixed farming systems were first formally recognized in 1998, and then in the CAP Strategic Plans 2007-2013. The current CAP Strategic Plans 2023-2027 supports the development of agroforestry and mixed farming systems in several ways. This includes some Good Agricultural and Environmental Practices (GAECs), agri-environment-climate measures and investment-measures. Additionally, the plans include Eco Schemes which encourage farmers to adopt practices favorable to biodiversity.

This European policy framework is further supported by national and regional programs in the studied European regions: France, Italy, and Spain.

Beyond Europe, Algeria and Egypt have made notable progress in integrating agroforestry and mixed farming to their national development agendas. The Algerian Ministry of Agriculture has opened lines for the development of agroforestry and mixed farming under the National Rural Development Fund (FNDR) and the National Fund for the Regulation and Development of Agriculture (FNDRA)[13]. In Egypt, these practices are embedded within the broader Egypt Sustainable Development Strategy to 2030 and Egypt Vision 2030[14].

Despite increasing interest, agroforestry and mixed farming remain underdeveloped and not fully integrated into agricultural systems across the Mediterranean basin. To enhance their adoption at the regional level, it will be crucial to strengthen their existing legal frameworks, while supporting local and regional programs and initiatives to encourage these practices.

However, the results of the Transition project's White paper analysis of policy barriers, together with previous research, highlights that significant differences persists between countries and regions[15]. It has evidenced that only a small sample of actors have knowledge about agroforestry and mixed farming. Bridging this gap will require coordinated efforts from governments, institutions and the farming community.

To raise awareness and promoting agroforestry and mixed farming among public and private stakeholders in the agricultural, livestock and forestry sectors is essential for their development.

The current challenge is to expand this knowledge to a wider audience, while supporting and linking existing local initiatives. To effectively reach farmers on a larger scale, it will be crucial to engage the professionals who work with and advise the farming community.

Knowledge sharing could be promoted through digital platforms such as Landfiles[16], a web and mobile application for observing, sharing and analyzing farmers' practices. Landfiles has developed a methodology for facilitating farmers and technicians groups, focused on the production of agronomic content. This content allows users to explore technical practices for plots and interact with group members.

This approach has successfully engaged both small and large collectives, gradually involving farmers and technicians in reading content and sharing information.

Today, for example, the Spanish Landfiles group 'Comunidad de sistemas agroforestales y cultivos mixtos', which is working with the Transition project, has managed to bring together 153 members interested in agroecological practices in Spain.

This group allows members to :

- Access information on how agroforestry systems and mixed farming can increase productivity, profitability and sustainability.

- Learn from the experiences of farmers using these systems and be informed about relevant conferences, courses and publications.

- Share experiences, ask questions and network within a community of experts, scientists and farmers to advance knowledge on resilient farming systems.

4. How can agroforestry and mixed farming be further promoted in the Mediterranean region?

As a result of the study carried out during the Transition project, which analyzed four main areas, public decision-makers must intervene to promote agroforestry and mixed farming practices and achieve the change of scale required for a sustainable future for agriculture adapted to climate change.

The actions proposed in this chapter are designed for the Mediterranean basin as a whole. However, they are neither exhaustive nor of equal importance depending on the region concerned.

Legislation, policies and subsidies

Challenges

Although there is growing interest in developing agroforestry and mixed farming in terms of public support, more needs to be done. The cost of developing a new model remains high for most farmers, making the transition to new systems difficult.

Access to land can be a major challenge for farmers. Without adequate access to suitable land or the ability to fully utilize the land they farm; farmers struggle to develop new farming systems.

Transforming agriculture requires a long-term vision and strong political commitment. It also requires social change and openness to new perspectives. A holistic approach is needed, integrating agriculture, livestock, and forestry rather than viewing them as separate sectors, at both administrative and policy levels. Decision-makers face the challenge of balancing long-term goals with immediate priorities to effectively promote agroforestry and mixed farming.

Proposed solutions

- Develop legislation to promote and regulate agroforestry and mixed farming systems.

- Develop incentives and funding programs to support agroforestry and mixed farming systems in southern Mediterranean countries.

■ Open public loans and self-financing through banks other than the national banking system in the Southern Mediterranean countries.

■ Strengthen the existing financial subsidies:
  ○ Developing payments for environmental services, such as grants, tax exemptions, cost-sharing programs, micro-credits or in-kind contributions, environmental certification of wood products and other sustainably produced goods, and greater integration with carbon markets.
  ○ Create a clear framework for payments for environmental services.
  ○ Promote a subsidy scheme (for fertilizers, irrigation, or water supply systems) linked to technical monitoring.
  ○ Establish a GAEC dedicated to agroforestry systems within the future CAP.

■ Expand land availability for small farms, with a particular focus on those pursuing agroecological practices:
  ○ Improve access to land tenure and/or land expansion for smallholders.
  ○ Facilitate access to land for farmers, developing value-added agroforestry and mixed farming with long-term contracts and/or "land banks".

■ Promote the creation of an "agroforestry" category in the land parcel system/cadastre could be useful for recognition and legitimacy, for access to funding and support, to improved land management, to enhance data collection and analysis, to facilitate land use planning, and to strengthening policies.

■ Decision-makers must act on multiple levels to ensure that future agricultural practices align with the principles of agroecology and effectively integrate mixed farming and agroforestry. This involves establishing long-term objectives and commitments while collaborating closely with rural communities and territories.

Awareness raising and capacitation

Challenges

The expansion of agroforestry and mixed farming faces significant challenges in terms of awareness and capacity building. Many farmers and stakeholders lack a clear understanding of the benefits and principles of agroforestry, which hampers their willingness to adopt these practices. Inadequate training leaves both farmers and public officials ill-equipped to effectively implement and support these systems. Furthermore, limited dissemination of relevant knowledge limits cooperation between local actors, while the lack of established networks makes it difficult to share best practices. In addition, the lack of visibility of successful agroforestry initiatives hinders wider uptake, as potential adopters may remain unaware of viable models. Overcoming these challenges is essential to promote the growth of sustainable agroforestry and mixed farming practices.

Proposed solutions

- Strengthen agroforestry training for public administrations in charge of applying the regulations.

- Publish and disseminate knowledge on mixed farming and agroforestry systems on a larger scale, promoting synergies between local actors, farmers and technical advisors.

- Establish and develop national and international networks of agroforestry and mixed farming practitioners.

- Publicize existing pilot farms and innovative agroforestry and mixed farming sites.

- Connecting farming communities to agroforestry locally and internationally through a support network (e.g., Landfiles).

- Integrate knowledge of agroforestry and mixed farming into the teaching programs of agricultural colleges, technical diplomas and universities.

- Create publicity spots and events explaining the benefits of agroforestry and mixed farming.

■ Create territorial initiatives involving municipalities, farmers, rural actors and local citizens.

■ Popularise business systems that show economic opportunities that can lead to the adoption of agroforestry and mixed farming systems.

Marketing and economics

<u>**Challenges**</u>

To better understand the slow pace of change in farming practices, it is necessary to analyse the fact that many farmers have limited visibility of the economic opportunities that changing their practices could bring. As a result, many farmers are reluctant to adopt new practices without clear evidence of profitability and sustainability.

In addition, the supply of seedlings is another critical issue that needs attention. The study conducted by the Transition project reveals a mismatch between supply and demand, which poses a significant challenge for farmers wishing to implement agroforestry projects.

<u>**Proposed solutions**</u>

■ Enabling market access for agroforestry and mixed farming products:
  ○ Showcasing the long-term benefits but also providing farmers with concrete examples of successful transitions.
  ○ Offering practical tools, such as business models and case studies, can help bridge this knowledge gap and demonstrate the viability of agroforestry and mixed farming. These tools enable farmers to see how diversifying their operations can generate new income streams and increase their resilience in the face of market and climate challenges.
  ○ Collaborating with the private sector will be crucial for integrating agroforestry and mixed farming into agricultural supply chains. A practical step could be incorporating agroecological practices into the procurement standards for agricultural products.
  ○ Create and encourage private funding for agroforestry and mixed farming through corporate social responsibility policies and private foundations.

- Improve seed supply and homogenise the nursery supply market in all areas, to help farmers with their planting projects.

- Promote the products of agroforestry farms (labels, brands, marketing…) in synergy with other agricultural products with added value from agroecological practices.

> For example, the Transition project has developed a catalogue of business models. It includes descriptions of six agroforestry and mixed farming systems tailored to the northern and southern fringes of the Mediterranean basin. It also examines successful enterprises in each region to serve as examples for farmers. These economic models are based on real conditions and have been adapted to provide practical solutions for the development of new value chains driven by farm diversification. Further information can be found in Deliverable 3.4 of the Transition project.

Technical challenges

Challenges

At present, there is a shortage of trained specialists in agroforestry and mixed farming techniques. In the near future, it will be essential to increase the number of trained professionals to help farmers make the transition.

In addition, the limited development and availability of crops suitable for agroforestry results in a narrow range of varieties that may not meet the diverse needs of farmers wishing to adopt agroforestry practices. As a result, farmers face challenges in accessing appropriate seedlings that can thrive in mixed systems, hindering the adoption of sustainable agricultural practices.

Proposed solutions

- Foster synergies between nurseries and scientific research to better market crops and varieties that are well-suited for agroforestry, such as late-flowering trees, vertically-rooted species, and shade-tolerant crops.

- Enhancing monitoring will be crucial to promote the larger-scale development of agroforestry and mixed farming systems.

- Train more professionals in agroforestry and mixed farming.

- Develop technical training for farmers in mixed farming and agroforestry.

- Integrate long-term technical support into support programmes.

- Open more grants for research in agroforestry and mixed farming.

For example, the <u>French School of Agroforestry</u>, created by the French Agroforestry Association in 2022, aims to address this need. Similar initiatives should be developed in each country and linked internationally to facilitate the exchange of knowledge and field experience.

5. Conclusions

Agroforestry and mixed farming systems are widely recognised as effective solutions for promoting economically, environmentally and socially sustainable agriculture that is resilient to climate change in the Mediterranean context. Moreover, as this document confirms, these systems offer valuable approaches to enhancing food security in both northern and southern Mediterranean countries.

These practices are increasingly recognised by public authorities and legislators, and are attracting growing interest from farming communities, who are now seeking technical, economic and political support to facilitate their transition.

This collaborative effort aims to provide decision-makers with a comprehensive set of solutions for a successful agro-ecological transition in agriculture across the Mediterranean basin.

While changing agricultural practices requires a medium- to long-term vision, the effects of global change are becoming more evident every year. It is therefore imperative to act quickly at local, national and international levels.

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