




PREPARING THE NEXT GENERATION OF PROFESSIONALS FOR RESILIENCE IN AGROECOSYSTEMS

The research of the “SARe Master of Science” students

AY 2023/2025

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CIHEAM, International Centre for Advanced Mediterranean Agronomic Studies, is an intergovernmental organization whose missions are education, research, and cooperation. It comprises thirteen member countries from the Mediterranean region (Albania, Algeria, Egypt, France, Greece, Italy, Lebanon, Malta, Morocco, Portugal, Spain, Tunisia, and Turkey). CIHEAM's General Secretariat is based in Paris and CIHEAM Bari is the Italian Institute of the organization, with the other three institutes based in Montpellier (France), Saragoza (Spain) and Chania (Greece).

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Introduction

CIHEAM Bari, under its educational mission, organizes master courses aimed at preparing international students to deal with the next decades challenges for agricultural and rural development. The Master of Science on Sustainable Agroecosystems and Resilience (SARe) is one of these courses[1] and prepares selected students to facilitate processes for agroecological transitions. They learn to work with an agroecosystem perspective, where agroecosystems are intended as territories with complex socio-ecological features that need a deep understanding, and where stakeholders, in coordination and connections, have to act for responding to drivers of change in the farming systems. The course is organized with a 1st year aimed at building students' knowledge and skills on theoretical and practical frameworks, and a 2nd year dedicated at creating their capacities in research and project development in the agriculture sector.

The research is a key part of students' activity during which they are demanded to explore, in a practical way, specific agricultural challenges in selected agroecosystems in their home countries. Through processes that include literature review, field observations, interviews with local actors, GIS applications, and other tools, they collect data and information and reflect on the nature of phenomena under investigation. The research develops students' skills in analysing and understanding the complexity of the evolution processes in agroecosystems, preparing them in acting with a multidisciplinary, intersectoral and territorial perspective.

All the research are supervised by experts from research centres, universities and other organizations, based in students' home countries and from CIHEAM Bari. Students present and discuss their results in front of an international board of experts.

This report[2] presents the extended abstracts of the students' research of the Academic Year 2023/2025. They were 6, representing the following countries: Egypt, Morocco, and Tunisia. The table below reports the students' list and the title of their research. Each abstract is structured in four parts that focus on the background and research objectives, the applied methodology, the main achieved findings, selected references on the topic.

The objective of the booklet is to give value to the students' activities and experience, and wish that, going through it, other youths would be inspired and encouraged to contribute to a sustainable development of agriculture and rural areas.

[1] Website: https://www.iamb.it/education/masters/sare/

[2] The report of AY 2021-2023 is available on https://www.iamb.it/wp-content/uploads/2024/03/Students-research.pdf; AY 2022-2024 https://www.iamb.it/wp-content/uploads/2025/01/FINAL-REPORT-SARE-2022-2024.pdf

Name	Country	Research title
Youmna Mohamed Gouda Abdelrahman KHALEL	Egypt	Understanding perceptions of smallholder farmers about intercropping as an agroecological practice: opportunities, challenges and future actions
Fatima Ashraf Salem Farag OMRAN	Egypt	Socio-economic impacts of Carbon Credit Certification on farmers facing climate change: case study of Beni Suef, Egypt
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Understanding perceptions of smallholder farmers about intercropping as an agroecological practice: opportunities, challenges and future actions

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Supervisors: F. Abo El Abbas (Ain Shams University, Egypt), G. Calabrese (CIHEAM Bari, Italy)

Introduction

Agriculture is an important activity in Egypt that contributes to around 14% of the GDP and employs over 20% of the national workforce. However, many are the challenges in farming. These include water scarcity, soil degradation, low productivity, and increasing climate vulnerability. Questions are about how the dominant input-intensive monoculture systems will be able to sustainably contribute to the food security and economic needs of the Egyptians.

Agroecology is emerging as a powerful paradigm for transforming agricultural systems by integrating ecological principles into farming and fostering biodiversity, resource efficiency, and social equity. Among agroecological practices, intercropping—the simultaneous cultivation of two or more crops on the same field—offers promising advantages such as enhancing soil fertility, improving pest and weed control, increasing land productivity, and ensuring greater climate resilience.

Despite its potential, intercropping adoption in Egypt remains limited. This gap can be attributed to a combination of socioeconomic, institutional, and technical constraints, as well as the limited availability of farmer-centered research on the topic. There is a pressing need to understand how smallholder farmers perceive intercropping, what benefits or challenges they associate with it, and what support mechanisms can foster broader adoption.

Under this framework, the present study aimed to provide a comprehensive understanding of the perceptions, experiences, and constraints of smallholder farmers regarding intercropping as an agroecological practice.

Specifically, the study aimed at:

- exploring about intercropping practices used by farmers.
- understanding who the users are and their motivations and perceptions of intercropping practices.
- exploring challenges and constraints that limit a wider diffusion.
- recommending policy, extension, and research interventions to support intercropping adoption as part of a broader agroecological transition.

Methodology

This research was carried out in two agriculturally significant Egyptian governorates: **Fayoum** and **Beni Suef**. Fayoum, particularly the Youssef El-Siddiq Center, is located in northwestern Egypt and is known for its hot desert climate and its agricultural resilience, largely due to the Bahr Youssef canal, which connects it to the Nile River. Despite low rainfall, its 51,500 acres of cultivated land have supported agriculture for generations. In contrast, Beni Suef, specifically the village of Ma'sara Na'san in the Ahnesia Center, is characterized by a semi-arid desert climate with frequent dusty windstorms such as the Khamassen. About 85% of the inhabited area is used for agriculture, and the village population is around of 4,500 people. Both areas were documented

through aerial photography analysis and field visits, and they serve as representative agroecosystems where smallholder farmers actively engage in intercropping and monocropping.

Aerial View of Youssef El Siddiq Village, Fayoum Governorate

Aerial View of Maasaret Naasan Village, Beni Suef Governorate

The study adopted a mixed-methods design, combining quantitative surveys to identify trends and correlations with qualitative interviews to capture farmers' motivations, challenges, and perceptions. For the survey, since no official records of intercropping farmers existed, a purposive sampling strategy was used with the support of local agricultural engineers, selecting 80 smallholder farmers equally divided between Fayoum and Beni Suef (20 intercropping and 20 monocropping in each). Before full-scale data collection, the research instruments were pilot tested with five farmers from the target areas to ensure that survey and interview questions were culturally relevant, clearly phrased, and appropriately targeted. Data were analyzed using descriptive statistics.

For the qualitative research, data were collected through semi-structured interviews (30–45 minutes, in Arabic) and a structured survey covering demographics, intercropping practices, barriers to adoption, economic viability, and knowledge sources. Interviews were held in convenient community locations to foster trust, and responses were complemented with qualitative observations, ensuring both breadth and depth of analysis. Qualitative data from interviews were transcribed and thematically coded to extract recurring patterns and farmer narratives around benefits, barriers, and support needs. Photos and observational notes were also collected to provide visual documentation, enriching the dataset.

Survey with Farmers in Fayoum

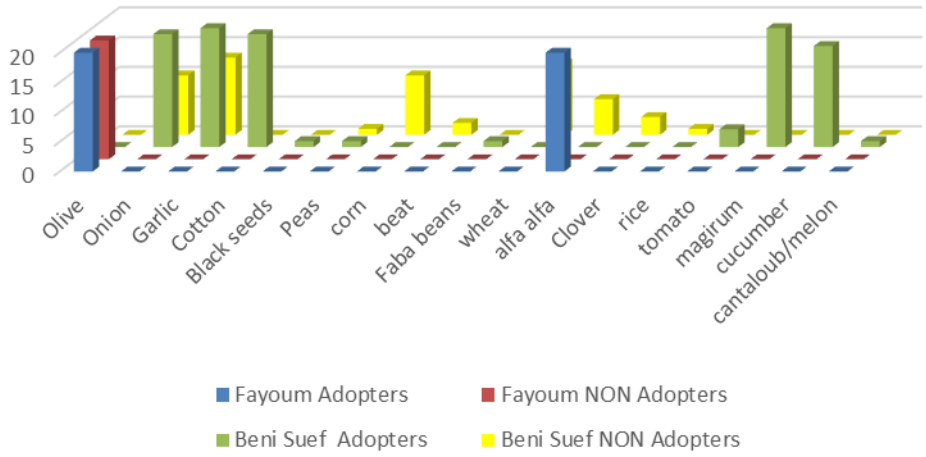
Survey with Farmers in Fayoum

Survey with Farmers in Beni Suef

Main findings and conclusions

The study provided significant insights into how smallholder farmers in Fayoum and Beni Suef perceive and practice intercropping within their agroecosystems.

Distinct intercropping patterns were identified across the two study areas, reflecting both ecological adaptation and local farming traditions. In Fayoum, farmers primarily practiced intercropping of olive trees with alfalfa (Medicago sativa). This combination serves multiple purposes: alfalfa functions as a nitrogen-fixing legume that enriches soil fertility, reduces weed growth, and provides animal fodder, while olive trees benefit from improved soil structure and moisture retention. The integration of perennial and forage crops demonstrates farmers' understanding of resource efficiency and long-term soil management under Fayoum's dry conditions. In Beni Suef, more diversified intercropping arrangements were documented. Farmers typically intercropped onions, garlic, or cotton with cucumber, tomato, or Pelargonium graveolens (rose geranium). These combinations are selected based on seasonal compatibility, market demand, and pest management benefits. For instance, P. graveolens is valued for its essential oil production and its ability to repel certain pests, while the vegetable pairings (such as onion–cucumber or garlic–tomato) help optimize land use and income diversification. Overall, these systems demonstrate farmers' capacity to integrate traditional knowledge with practical innovation to sustain productivity and resilience in semi-arid environments.



Farmers Crops and Intercropping Adoption

Farmers who practiced intercropping reported several agronomic and economic benefits, including increased land productivity through more efficient use of space and resources, improved soil fertility and moisture retention (especially with legumes), and reduced pest incidence that lowered the need for chemical pesticides. They also highlighted greater crop diversity, which enhanced household food security and income stability, as well as better adaptation to climate variability and reduced risk of crop failure. These perceptions demonstrate a practical understanding of agroecological principles and emphasize that intercropping, while knowledge-intensive, offers significant benefits for smallholder farmers.

Likert Scale Analysis of Farmers' Perceptions of Intercropping in Fayoum and Beni Suef

Perception Variable	Fayoum (Mean, SD)	Beni Suef (Mean, SD)	Most Common Response (Fayoum)	Most Common Response (Beni Suef)	Interpretation
Improves Soil Heath & Fertility	1.95, 1.01	2.48, 0.87	52.5% Agree	72.5% Disagree	Farmers in Fayoum are more likely to believe intercropping improves soil health, whereas most in Beni Suef disagree
Increases Income Diversity	1.33, 0.73	1.35, 0.77	82.5% Agree	82.5% Agree	Farmers in both regions strongly agree that intercropping helps diversity income sources
Improves Pest & diseases Control	1.90, 1.00	2.60, 0.81	55% Agree	80% Disagree	Farmers in Fayoum widely perceive pest control benefits, whereas most in Beni Suef do not

The majority of farmers expressed a willingness to continue the practice, citing both short-term and long-term benefits, with a good share of farmers who have interest in experimenting with intercropping if provided with technical support and financial incentives. This openness indicates a significant potential for scaling intercropping, particularly through participatory approaches and farmer-to-farmer knowledge exchange.

The adoption of intercropping is influenced by socioeconomic factors. Younger and more educated farmers tended to be more open to experimentation and innovation, while larger landholders were more likely to adopt intercropping due to the flexibility offered by greater land availability. Regular access to agricultural extension services also played a key role, as farmers who engaged with agricultural engineers were better informed about the practice. In addition, peer influence was significant, with many farmers relying on neighbouring practices as informal learning sources, which shaped their decisions about adopting intercropping.

Willingness to Continue / Try Intercropping

Location	Total Farmers Surveyed	Willing to continue/ try intercropping	Uninterested in intercropping	% Willing	% Non-willing
Fayoum	40	36	4	90%	10%
Beni Suef	40	32	8	80%	20%

Most the adopting farmers did not mention big challenges for the provision of seeds for intercropping (coming from the precedent harvest or from farmer's associations), neither for the products marketing. Many of them evidenced the need of information about irrigation and fertilization in intercropping practices. The research concluded that intercropping is a valuable agroecological practice with clear benefits recognized by smallholder farmers in Egypt. It also showed that adopter farmers have a valuable knowledge on intercropping and do it with awareness and gain agronomic and economic benefits. However, intercropping diffusion is constrained by knowledge gaps, institutional weaknesses, and infrastructural limitations. The findings underscore also the importance of aligning technical solutions with social, cultural, and institutional realities to ensure lasting impact in rural Egypt.

Finally, to foster farmers adoption of intercropping:

- Policies should focus on capacity building, with locally tailored extension services.
- Demonstration plots must be established, possibly in farmers' fields.
- Strengthening community-led innovation and peer learning can help overcome cultural barriers and promote bottom-up adoption. Farmer field schools can be used to showcase successful intercropping models.

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Socio-economic impacts of Carbon Credit Certification on farmers facing climate change: case study of Beni Suef, Egypt

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Introduction

Climate change is widely recognized as one of the most pressing challenges of our time, exerting profound and far-reaching impacts on ecosystems, economies, and societies. Agriculture, positioned at the intersection of climate vulnerability and responsibility, plays a dual role: while it suffers heavily from the consequences of climate change, it also contributes significantly to greenhouse gas emissions through soil degradation, deforestation, and the use of chemical fertilizers. Yet agriculture also holds part of the solution. Through improved land management, conservation tillage, and organic soil practices, it can act as an effective carbon sink, sequestering carbon and offsetting emissions.

Within this global context, the Carbon Credit certification system has emerged as a strategic tool to promote environmentally responsible farming. By providing measurable and tradable incentives for emission reductions, this mechanism encourages farmers to adopt good agricultural practices that mitigate emissions but also enhance soil fertility, biodiversity, and long-term farm productivity.

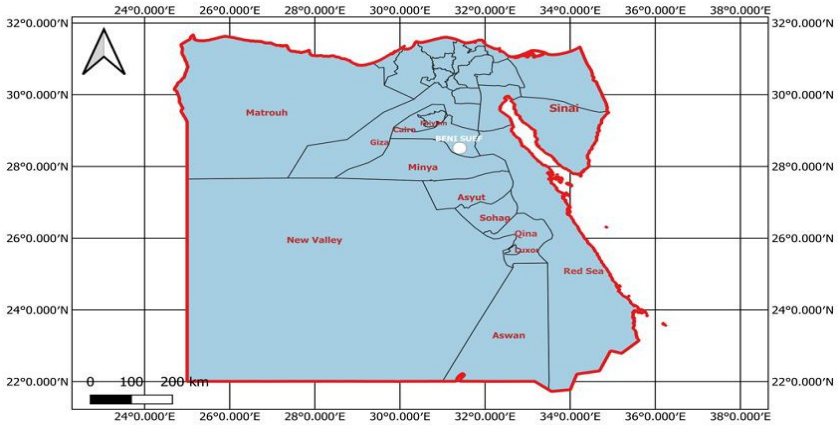
Egypt represents a particularly relevant case for such a transformation. Although the country contributes only about 0.6% of global carbon dioxide emissions, it is among the nations most vulnerable to the effects of climate change. Rising temperatures, recurrent droughts, and increasing soil salinity are jeopardizing food security and threatening the livelihoods of millions of rural households. The Egyptian agricultural sector is characterized by small-scale farmers managing plots of less than one hectare, many of whom have limited access to resources and technologies that could help them adapt to climate change. For this reason, promoting and diffusing Carbon Credit certification among Egyptian farmers is not only a matter of environmental urgency, but also of economic resilience and social equity.

Despite Egypt's participation in international climate agreements—such as the UNFCCC, the Kyoto Protocol, and the Paris Agreement—there remains a critical knowledge gap: little is known about how Egyptian farmers perceive and engage with Carbon Credit certification. Understanding farmers' perceptions is essential for the diffusion and success of such initiatives. Acceptance and adoption depend on whether farmers recognize certification as beneficial, feasible, and aligned with their economic realities. Without this understanding, policy instruments risk remaining underutilized or misunderstood.

Considering this, the present research was conceived to (1) explore farmers' perspectives on the challenges posed by climate change, (2) assess the socio-economic impacts of Carbon Credit certification on their livelihoods, and (3) identify agricultural practices with the highest potential for carbon sequestration. Through these objectives, the study not only evaluates the environmental and economic implications of certification but also provides insight into how farmers perceive, value, and experience it. In doing so, it supports the broader goal of integrating Carbon Credit mechanisms into Egypt's agricultural strategy—helping transform smallholder farming into a cornerstone of climate resilience and sustainable development.

Methodology

To address these questions, the research adopted a mixed-methods approach, combining qualitative and quantitative techniques. The study was carried out in Beni Suef, a governorate located in Egypt's Nile Valley, chosen for its concentration of certified farmers and its representative agricultural profile.



Beni Suef location

The target population was smallholder farmers, stratified by age, farm size, and adoption of sustainable practices. A sample of 50 farmers was selected and divided evenly: 25 farmers with Carbon Credit certification and 25 without. This comparative design enabled the study to isolate the effect of certification on various livelihood indicators.

FGDs on Carbon Credits

Data were collected in late 2024 and early 2025 through focus group discussions and structured personal interviews. FGDs captured farmers' experiences of climate change and their perceptions of certification, while interviews gathered quantitative data on income, education, health spending, and housing. Statistical analysis, including t-tests and correlation tests, was conducted using SPSS, while thematic analysis was applied to qualitative material. Ethical standards were observed throughout. All participants gave informed consent, data were anonymized, and findings were used solely for academic purposes.

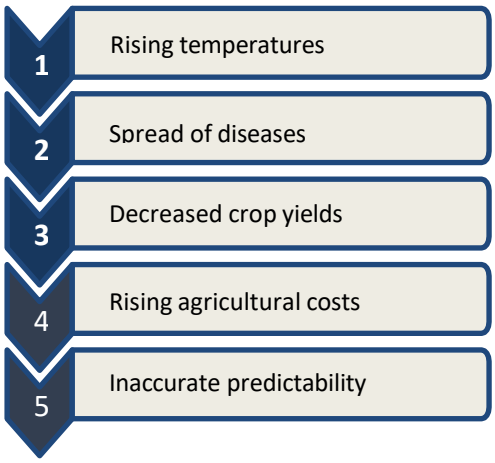
FGDs on Carbon Credits

Main findings and conclusions

What are the challenges faced by farmers when dealing with climate change in Egypt?

The findings reveal that interviewed farmers are acutely aware of the ongoing and intensifying impacts of climate change on their agricultural activities. Farmers no longer perceive climate change as a distant or gradual process; rather, they experience its consequences season by season, through increasingly unpredictable weather patterns and environmental stressors. Rising temperatures emerged as the most significant concern, associated with the spread of new pests and crop diseases — particularly potato rot and powdery mildew — which have collectively led to noticeable declines in productivity.

Many participants emphasized how temperature increases and erratic rainfall patterns have disrupted traditional planting schedules and reduced water availability. In response, farmers reported having to irrigate their fields more frequently, which in turn raised production costs and placed greater pressure on limited water resources. Some noted that seasons have become unpredictable: years of drought are often followed by heavy, unseasonal rains, leaving farmers uncertain about planting times and vulnerable to financial loss.



Climate change challenges faced by farmers

Livestock farming has also suffered under heat stress conditions. Several farmers described reduced milk yields and reproductive difficulties among their animals, while others reported the emergence of prolonged diseases such as foot-and-mouth, which have not only affected productivity but also increased veterinary costs.

Despite these challenges, the results demonstrate a remarkable level of adaptive capacity and awareness among farmers. Many are willing to adopt new strategies, provided they have access to information and resources. Some participants expressed the need for early-warning systems and training on suitable planting calendars, while others emphasized the importance of transitioning to modern irrigation systems, especially drip irrigation, to conserve water. A smaller but noteworthy group highlighted the value of compost and organic fertilizers, perceiving them as affordable, sustainable methods for improving soil health and resilience. Overall, farmers displayed a deep understanding of the environmental pressures affecting their livelihoods

and a pragmatic attitude toward adaptation, though financial and technical constraints remain significant barriers.

How does Carbon Credit certification contribute to improving farmers' overall quality of life?

The introduction of Carbon Credit certification among smallholder farmers has had a measurable and positive impact on their socio-economic conditions. Comparing certified farmers (the experimental group) with non-certified farmers (the control group) revealed several key areas of improvement directly linked to participation in the certification program.

Certified farmers reported higher incomes, often more than double those of non-certified counterparts, which enabled them to reinvest in their farms and households. The additional revenue derived from Carbon Credit payments and premium prices for certified products translated into improved spending on education and healthcare. Many participants in the certified group noted that they were able to keep their children in school longer or access better educational resources, reflecting an increase in both income stability and long-term household resilience. Likewise, expenditure on health services increased, signaling enhanced living standards and awareness of well-being.

Housing conditions also improved significantly among certified farmers. Interviews revealed that the extra income from Carbon Credits was often used to renovate homes, purchase household appliances, and improve access to clean energy sources. Ownership of electrical devices—such as fans, refrigerators, and irrigation pumps—was higher in the certified group, further supporting the link between certification and material welfare.

Differences between the means of the two groups due to the carbon credit effect on money spent on education, health, house condition and farmer's total income

Interestingly, the research found that these economic benefits were accompanied by changes in farmers' outlooks and values. Participants described feeling more integrated into a broader environmental mission, expressing pride in contributing to climate mitigation while simultaneously improving their livelihoods. This dual benefit—economic and ethical—strengthened farmers' motivation to maintain sustainable practices and created a sense of belonging to a global movement of climate-conscious producers. However, some participants also expressed uncertainty about how Carbon Credit prices are determined, suggesting that greater transparency and farmer education could further enhance trust and participation.

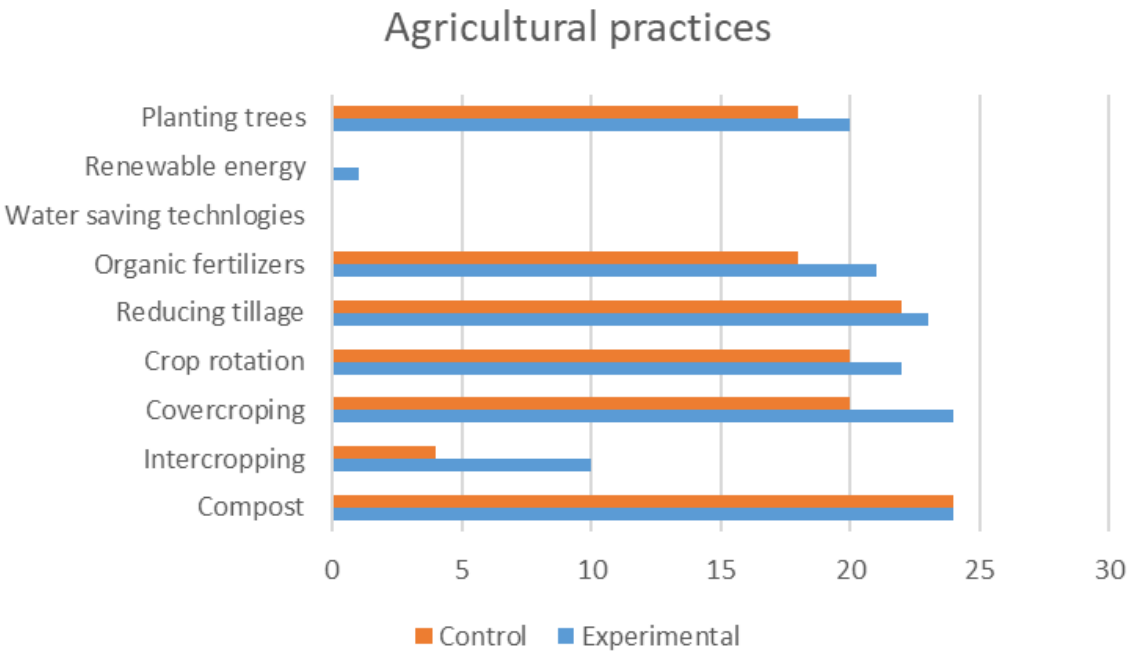
In sum, Carbon Credit certification has proven to be more than a financial mechanism; it has become a pathway toward socio-environmental empowerment, encouraging farmers to view sustainable agriculture not as an obligation but as an opportunity for growth and dignity.

Which agricultural practices have the highest potential for carbon sequestration?

The study identified several agricultural practices that are both climate-resilient and capable of contributing significantly to carbon sequestration. Among these, composting, cover cropping, crop rotation, reduced tillage, and integrated nutrient management emerged as the most common and effective approaches adopted by certified farmers.

Composting was viewed by nearly all participants as a transformative practice. Farmers noted visible improvements in soil texture, fertility, and moisture retention after consistent compost application. These observations align with scientific evidence that organic amendments increase soil organic carbon and microbial activity, enhancing the soil's capacity to capture and store carbon over time. Similarly, cover cropping and crop rotation were cited as key strategies for maintaining soil vitality and reducing pest infestations.

Practices done by Control and Experimental groups



Another critical element was the use of drip irrigation systems, which minimize water loss and energy consumption. Farmers reported that these systems not only conserve resources but also prevent soil erosion, indirectly supporting carbon retention in agricultural soils. In addition, the adoption of biodynamic and organic principles promoted by the Egyptian Biodynamic Association further strengthened farmers' understanding of how sustainable agriculture can align with climate mitigation objectives.

Importantly, the motivation behind adopting these practices extended beyond financial returns. Many farmers spoke about protecting their land for future generations and ensuring the longevity of their farms. This intergenerational perspective underscores that farmers are motivated by a mixture of economic incentives and moral responsibility balance that Carbon Credit certification effectively reinforces.

Overall, the research demonstrates that climate change poses serious threats to Egyptian agriculture, yet it also reveals pathways toward resilience and sustainability. Carbon Credit certification plays a pivotal role in this transformation by promoting environmentally sound farming practices and improving farmers' socio-economic well-being. Furthermore, by documenting how farmers perceive, experience, and benefit from certification, this study contributes valuable insights into how such programs can be expanded and adapted to other regions of Egypt. Ultimately, the findings affirm that empowering farmers through financial incentives and knowledge-sharing can simultaneously strengthen rural livelihoods and advance national climate goals.

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Agroecological practices and transition pathways in olive farming systems: a multifunctionality-based analysis in Sidi Kacem province, Morocco

Author: Wiam Moumen (Morocco)

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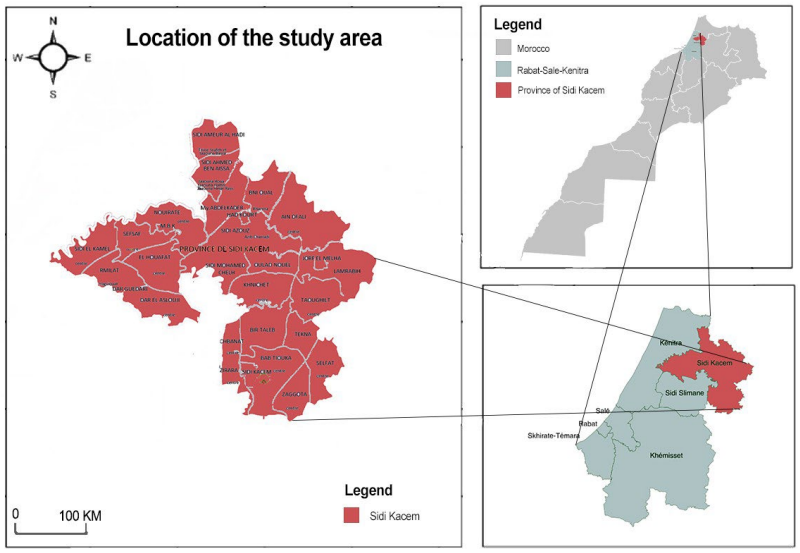
Introduction

The province of Sidi Kacem, in northwestern Morocco, offers a vivid illustration of the profound transformations taking place in Mediterranean agriculture. Once a landscape dominated by cereal production, the area has, in recent decades, experienced a rapid expansion of olive cultivation. This shift has been encouraged by national policies such as the Green Morocco Plan and Generation Green 2020–2030, designed to modernize the agricultural sector and strengthen its contribution to the national economy. Yet, while olive trees now stand as a symbol of new opportunities, their spread has also exposed the fragility of local resources. Water scarcity, recurrent drought, rural exodus, and environmental degradation are all pressing realities in the region, highlighting the urgent need for more sustainable farming models.



Location map and administrative territorial boundaries of the province of Sidi Kacem

At the heart of this debate lies the concept of agroecology. Unlike conventional high-input agriculture, agroecology goes beyond production to embrace social, cultural, and environmental dimensions. It has been increasingly promoted worldwide as a pathway to restore ecosystems, strengthen rural communities, and build resilience in the face of climate change. But in Morocco, and particularly in Sidi Kacem, questions remain about what such a transition might look like in practice. How do existing olive farming systems function? To what extent do they already incorporate agroecological principles, knowingly or not? And how might their multifunctional roles—economic, social, and environmental—support a gradual transition?

This research sets out to explore these questions. Its general aim was to understand the multifunctional nature of olive farms in Sidi Kacem and to use that understanding to propose strategies for agroecological transition. More specifically, it sought to characterize the different functions olive farms perform, to identify and analyze the agroecological practices already in place, and to suggest transition strategies tailored to different groups of farmers. Underlying these objectives were three hypotheses: that farms differ widely in their multifunctional roles; that adoption of agroecological practices varies across groups; and that farms with stronger social, cultural, and environmental functions are more naturally inclined toward agroecology than those dominated by purely economic concerns.

Methodology

The research unfolded as a journey in three stages, moving gradually from preparation to fieldwork and finally to analysis. The preparatory phase began with a careful review of literature on the olive sector, multifunctional agriculture, and agroecology. This provided not only a theoretical foundation but also a practical lens through which to approach the field. The choice of Sidi Kacem as a study area was itself strategic: the region encapsulates both the promise and the contradictions of Morocco's agricultural transition.

The second stage brought the researcher into direct contact with the farmers and their communities. Because no complete database of olive farmers was available, a snowball sampling technique was used, starting from a few contacts and gradually extending to sixty olive producers. Semi-structured surveys and interviews served as the main tools, combining open questions that encouraged farmers to tell their stories with closed questions that allowed quantifiable comparisons. The surveys were conducted in Moroccan Arabic, later transcribed and translated, ensuring accessibility while also capturing the nuances of local expressions and perspectives.

Meeting olive farmers

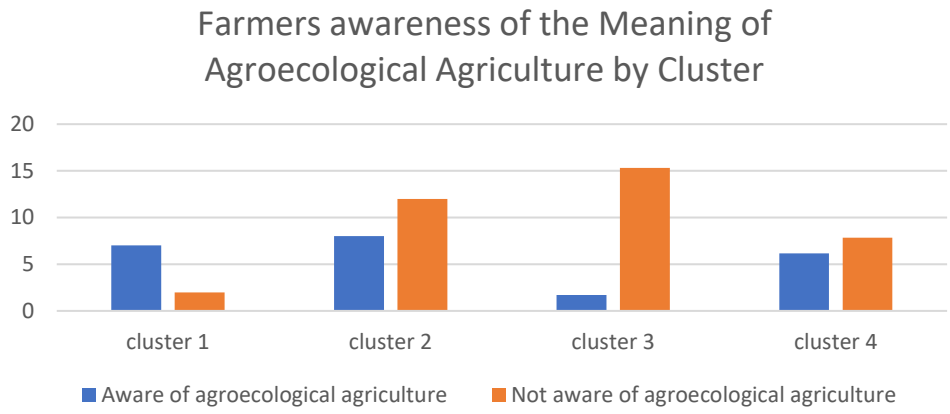
This phase of fieldwork was not without challenges. Building trust with farmers was often difficult: many initially feared that questions about production and land use might be linked to tax inspections. Timing was another obstacle, as interviews coincided with busy agricultural seasons, when farmers had little time to spare. Gender also played a role, as the young female researcher sometimes faced scepticism about her expertise in a male-dominated environment. Finally, the geography of the province, with its scattered communes and poor road connections, made travel demanding and time-consuming.

Once the data were collected, the analysis could begin. Farms were first described in terms of size, land allocation, and socio-economic characteristics. Then, a more sophisticated statistical approach was used to group them into types, highlighting patterns that went beyond individual cases. Farmers were ultimately classified into four main models: large agribusiness estates, entrepreneurial local farms, smallholder family farms, and mid-scale commercial farms. Within and across these groups, agroecological practices were identified and compared, providing a rich picture of the diversity of farming strategies in Sidi Kacem.

Main findings and conclusions

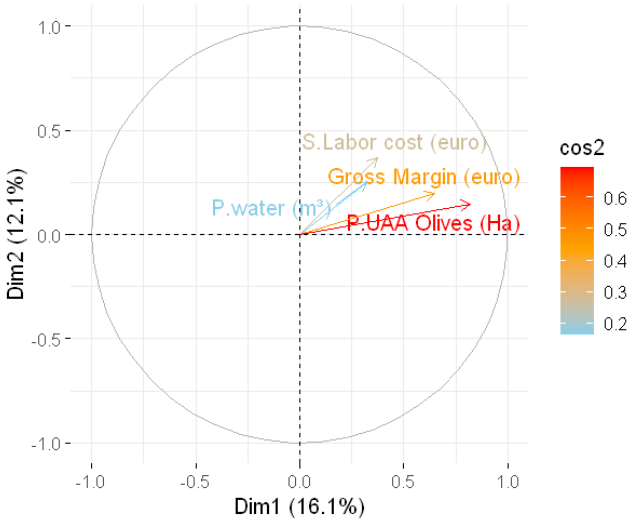
The findings revealed both the complexity and the potential of olive farming systems in the province. Farms were found to be deeply heterogeneous: some operated as large, profit-driven enterprises, while others remained small family holdings combining olive trees with crops, livestock, or traditional practices. Yet, across this diversity, one common theme emerged: all farms were multifunctional to some degree, simultaneously fulfilling economic, social, cultural, and environmental roles.

When it came to agroecology, awareness among farmers was generally low. The majority had never heard the term, and only a small minority could articulate its meaning. Nonetheless, agroecological practices were present in disguised forms: composting, crop diversification, use of manure, regulated deficit irrigation, or integration of livestock into farming systems. These practices were not necessarily adopted for ecological reasons, but often because they were affordable or aligned with traditional knowledge.



Farmer's awareness of the meaning of agroecological agriculture by cluster

The typology of farms highlighted striking contrasts. Agribusiness farms, though efficient and well-capitalized, showed little interest in ecological approaches, focusing almost exclusively on productivity. Entrepreneurial local farms were more promising candidates for agroecological transition, provided that financial and institutional support was made available. Smallholder subsistence family farms, despite limited resources, already practiced many forms of agroecology, often unconsciously, as part of their survival strategies. Mid-scale commercial farms fell somewhere in between, with moderate levels of diversification and potential to evolve if adequately supported.



Projection of quantitative variables

Graphical representation of the modalities of qualitative variables on the principal plane

These insights point to a clear conclusion: agroecological transition in Sidi Kacem cannot follow a one-size-fits-all model. Instead, strategies must be tailored to the specific profiles of farmers. Large agribusinesses may need regulatory incentives to adopt environmentally sound practices, while smallholders may benefit more from cooperative organization, access to markets, and recognition of their traditional knowledge. Mid-scale and entrepreneurial farms could serve as bridges, combining modern efficiency with ecological innovation.

Beyond the typologies, the study also underscored the importance of strengthening farmer organizations, promoting diversification, valuing local know-how, and improving access to financial and technical resources. Taken together, these measures could support a gradual but meaningful shift toward resilience and sustainability.

In the end, the research not only provided a detailed mapping of the olive sector in Sidi Kacem but also offered a broader lesson: that the path to agroecology lies in recognizing the multifunctional nature of farming. By building on the existing functions and strengths of farms—economic, environmental, and social—agroecology can move from being a distant ideal to a lived reality, adapted to the needs and potential of each farmer.

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Understanding opportunities for a dynamic conservation of Global Important Agricultural Heritage Systems (GIAHS): a participatory assessment of the Ramli system in Sidi Ali El Mekki lagoon, Tunisia

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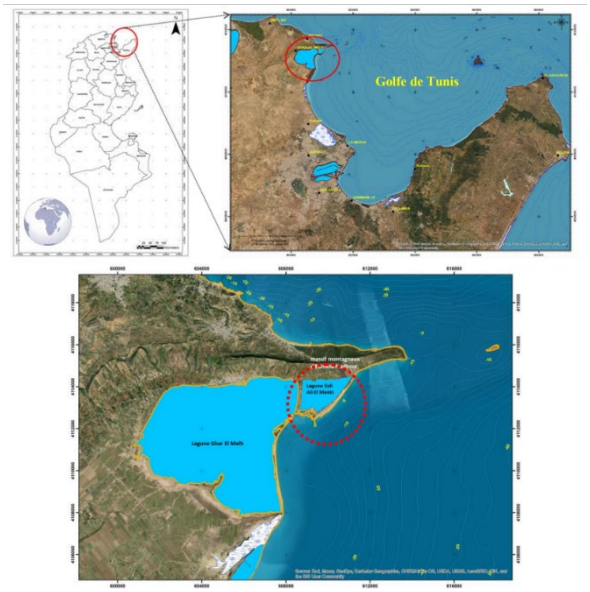
Supervisors: A. Sahli (INAT, Tunisia), M. Moretti (University of Pisa, Italy), L. Lamberti (CIHEAM Bari, Italy)

Introduction

The Ramli agricultural system of the Sidi Ali El Mekki lagoon in Tunisia is a remarkable example of human ingenuity and adaptation. Rooted in centuries-old practices, it represents an ingenious way of cultivating crops on sandy soil by making use of freshwater lenses formed beneath the surface. This method, recognized by the Food and Agriculture Organization of the United Nations (FAO) as a Globally Important Agricultural Heritage System (GIAHS), is more than a farming technique; it is a symbol of resilience, culture, and sustainability.



Map of Ghar El Melh and Sidi Ali El Mekki lagoons complex

Globally, agricultural heritage systems like the Ramli are under increasing threat. The spread of modernization, economic globalization, and climate change have placed tremendous pressure on traditional farming methods. The Ramli system is no exception. It has endured for generations, but today it faces a combination of ecological and social challenges: the effects of sea level rise and salinization, the loss of fertile land to urban expansion, the weakening of local institutions, and the gradual erosion of traditional knowledge as younger generations turn away from agriculture. Farmers who once proudly maintained their plots now struggle to sustain them against these converging forces.

This research set out to examine these challenges and to understand how the Ramli system could be safeguarded for the future. Its objectives were fourfold. First, it aimed to identify the threats and drivers of change affecting the system, considering both ecological disruptions and socio-economic pressures. Second, it sought to document the traditional knowledge and practices that have allowed the Ramli to survive for centuries. Third, it evaluated the cultural, ecological, and social values of the system, recognizing it not only as a means of production but as a living heritage. Finally, the study worked with local actors to co-construct recommendations and solutions that could ensure the system's dynamic conservation.

To achieve these goals, the research was inspired by the framework of Koohafkan and Altieri (2011), known as the "Framework for the Dynamic Conservation of GIAHS." This model emphasizes that heritage systems must evolve rather than remain static, adapting to modern challenges while preserving their essential identity. It promotes participatory approaches that empower local communities, integrate traditional ecological knowledge with modern science, and ensure that conservation efforts also respond to the aspirations of the

people who maintain these landscapes. In this way, the Ramli system is seen not only as a fragile remnant of the past, but also as a potential model for the future of sustainable agriculture.

Methodology

To address the research objectives, this study adopted a participatory approach rooted in the principles of Participatory Action Research (PAR). Unlike traditional research methods that separate observation from action, PAR emphasizes cycles of planning, action, observation, and reflection, engaging the community as active participants rather than passive subjects. This choice was particularly appropriate for the Ramli system, where statistical data are scarce and much of the relevant knowledge is held by farmers themselves, passed on orally through generations.

Meeting farmers during field visits

The research began with an extensive review of existing literature and policy documents. This helped to map the broader historical and institutional context of the Ramli system, but it quickly became clear that academic sources alone could not capture the lived realities of farmers or the nuances of local ecological practices. To bridge this gap, the researcher turned to the voices of the community. Exploratory interviews were conducted with experienced farmers and local development agents, who shared not only technical knowledge of cultivation but also memories of past events that had shaped the lagoon and its agricultural system. These conversations revealed recurring themes—such as hydrological changes, market constraints, and the decline of local varieties—that guided the next steps of the research. From these early engagements emerged a series of participatory tools designed to make the invisible visible. Farmers collaborated to create resource maps of the lagoon, highlighting the spatial divisions of land and the challenges unique to each zone.

Elaboration of participatory resource map of the lagoon of Sidi Ali El Mekki

Historical timelines were co-constructed to trace key events—from floods and infrastructure projects to policy shifts—that had marked the system's trajectory. Transect walks provided an on-the-ground view of how soils, water, and crops varied across the lagoon, while a sustainable livelihoods framework was used to analyse the human, natural, social, physical, and financial capitals that sustain local households. Building on this foundation, semi-structured interviews and focus groups were carried out with fourteen stakeholders, including farmers, union representatives, and development agents. These dialogues allowed for deeper exploration of the drivers of change, the threats to the system, and the strategies that farmers continue to employ. Importantly, they also fostered trust and dialogue among actors who often feel overlooked in decision-making processes.

Participatory workshop

The research culminated in a validation and restitution workshop held in January 2025. Farmers, representatives of agricultural institutions, and union leaders gathered to discuss the findings, verify the accuracy of the analysis, and collectively envision solutions. This workshop was more than a formal presentation; it was a space for exchange, negotiation, and co-creation, where the knowledge of local actors was not only acknowledged but integrated into the research outcomes. Through this participatory and iterative process, the research ensured that the story of the Ramli system was not told about farmers but with them. The implementation of the study, grounded in the principles of PAR, thus became both a method of inquiry and a step toward empowering local actors to reclaim ownership of their heritage and its future.

Main findings and conclusions

The findings of this research reveal that the Ramli agricultural system, while still functioning, is increasingly fragile under the weight of environmental, socio-economic, and institutional pressures. Farmers and stakeholders who participated in the study highlighted a system that embodies resilience, tradition, and ecological wisdom, yet one that is now at risk of fading away if urgent action is not taken.

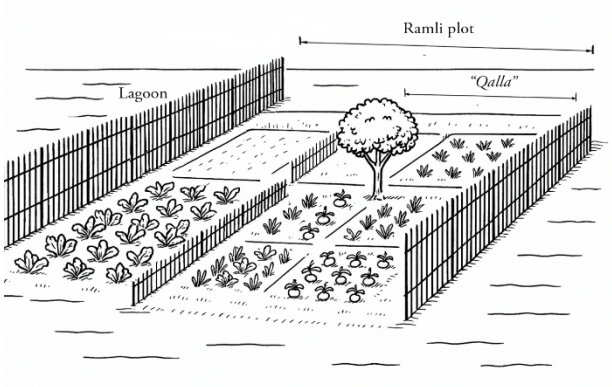


Illustration of a Ramli plot

(a)

(b)

(a). The "Tastira". (b)."Qalla" cultivated with various crops

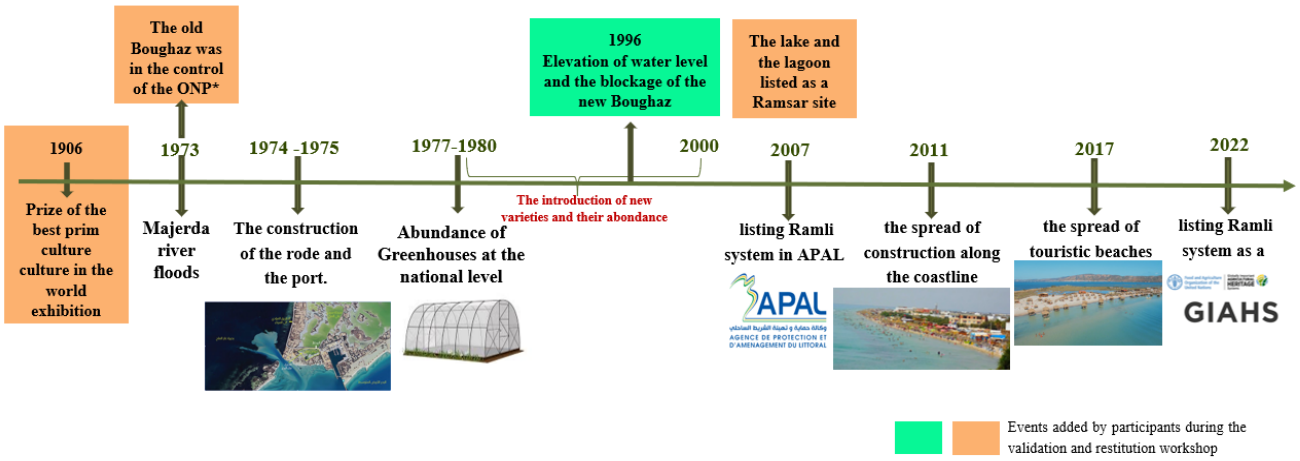
From an agroecological point of view, it is a very complex system, formed by different sub-systems named by farmers as El Hmaryet and El Njila, El Thraa, Gattaya, and El Hay. Each one has its own features and challenges, and farmers are still mastering the management of their plots according to the traditional way, with skills and competence.

		El Hmariyet (Marej) and El Njila	El Thraa	Gattaya	El Hay
Soil texture		**Color:** red **composition:** sand and clay (Mounting sedimentation)	**Color:** yellow **composition:** sand	**Color:** yellow **composition:** sand	**Color:** white **composition:** sand
Borders		• Mounting • Lagoon • Agriculture fields • Mounting • Lagoon • Sidi Ali el Mekki village	• Lagoon • lake	• Surrounded by the lagoon	• Lagoon • Mediterranean sea
Water resources		• Freshwater springs • Lagoon fresh water • Rain water • Walls	• Lake • Rain water • Lagoon fresh water	• Lagoon fresh water • Rain water	• Lagoon fresh water • Rain water • Sea water
Agricultural practices	Ploughing	• Animal • Machines • Manual	• Animal	• Manual	• Manual
	Fertilization	• mainly organic with medium chemical input		• mainly organic with lower chemical input	
	Seeding of main crop	• Normal plantation date		• 15 to 20 days delay in the plantation	• Normal plantation date
Environmental and agronomic challenges		• the Njila is highly effected by the wind (high wind erosion) • Invasive wild pigs destroying the yielding	• Wind erosion • risk of Submerging by salty water that effects the plants	• Higher risk of Submerging by salty water that effects the plants • Unstable water level • Wind erosion • Hardly accessible	• The Hay zone is highly effected by wind turbulent
Productivity		++	++	+	+++

Transect map of the Ramli system

Farmers have clear in minds the main events and reasons that are threatening the system and its integrity. They reported that strong winds and saline water intrusion have made it increasingly difficult to maintain soil fertility and ensure reliable harvests. The construction of infrastructure, particularly the port and road that disrupted the natural flow of water through the Boughaz canal, has disturbed the lagoon's hydrology. This disruption has weakened the delicate freshwater balance that the Ramli system depends on. Added to this are the pressures of climate change, which bring less rainfall, greater variability, and the looming threat of sea level rise. Together, these forces erode the ecological foundations of the system.

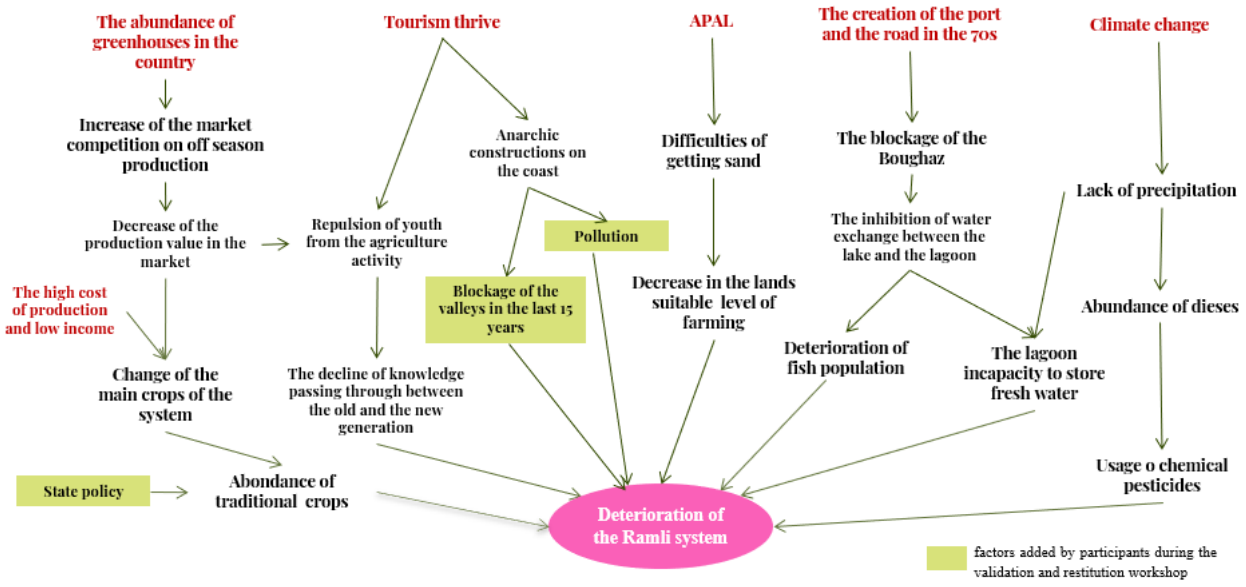
At the same time, socio-economic challenges place additional strain on the farmers. Many of them operate on small plots with low margins, facing rising input costs and market restrictions that leave them unable to secure a decent income. Younger generations increasingly turn away from farming, perceiving it as both physically exhausting and financially unrewarding. Instead, they seek opportunities in tourism or urban jobs. This generational shift not only reduces the labor force but also threatens the transmission of traditional ecological knowledge that has been passed down for centuries. Uncontrolled urbanization and the rapid growth of tourism have further displaced agricultural land and disrupted the fragile lagoon ecosystem. Farmers also expressed frustration at the lack of consistent institutional support and the overlapping responsibilities of different authorities, which have created confusion and mistrust.



Farmers' views about major events that have had an impact on the Ramli system

Despite difficulties, the research uncovered signs of strength and resilience within the system. Farmers have showed their concern to preserve the lagoon and its values, identifying the importance of programs to include the Ramli system in their policies (APAL and GIAHS). It remains a living testimony of traditional ecological knowledge, with farmers carefully maintaining soil levels, constructing protective windbreaks, and practicing intercropping and rotation to sustain productivity. These practices align closely with modern agroecological principles, demonstrating how local traditions can serve as powerful tools for sustainability. Beyond its ecological value, the system continues to provide cultural identity and community cohesion. Farmers still share seeds, exchange labor, and collaborate during key agricultural activities, even if some cultural practices have begun to fade.

They also have clear in minds the main reasons that are threatening the system and its integrity, and through the participatory workshop they contributed to define the territorial dynamics, proposing a range of solutions. One of the most urgent priorities identified was the restoration of the Boughaz canal to reestablish natural water exchanges between the lagoon and the sea. Participants also emphasized the need to provide greater support to active farmers through financial incentives, technical guidance, and institutional recognition of their role as custodians of this heritage. Economic viability could be strengthened by promoting Ramli products through certification, labelling, and niche markets that recognize their cultural and ecological value. Additionally, stronger local institutions and cooperatives were seen as crucial for rebuilding trust, fostering collective action, and amplifying farmers' voices in policy debates. Finally, participants suggested that integrating ecotourism and cultural valorization could create new sources of income, provided that such initiatives are carefully managed to avoid further damaging the ecosystem.



Farmers' territorial dynamic threatening the Ramli system

In conclusion, the research demonstrates that the Ramli agricultural system is at a decisive turning point. It continues to embody ecological balance, cultural resilience, and sustainable practices, yet it is undermined by a convergence of ecological degradation, socio-economic marginalization, and institutional neglect. The way forward lies in dynamic conservation strategies that combine local participation, policy support, and innovative approaches to ensure that the Ramli system remains a thriving example of harmony between people and nature.

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Evaluating Water Harvesting Techniques for mitigating land degradation in arid regions: the case study of Jeffara region Southern Tunisia

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Introduction

Land degradation has emerged as one of the greatest environmental challenges of our time, affecting ecosystems, economies, and societies on a global scale. It is estimated that around 40 percent of the Earth's terrestrial surface is moderately degraded, with nearly one-tenth classified as highly degraded. The consequences are severe: declining crop yields, the loss of ecosystem services, and the displacement of millions of people whose livelihoods depend on the land. These effects are particularly acute in arid and semi-arid regions, where fragile ecosystems and vulnerable populations are exposed to both climatic and socio-economic stressors.

Tunisia offers a striking example of this crisis. With nearly 80 percent of its land threatened by degradation, the country faces multiple pressures, including wind and water erosion, nutrient depletion, salinization, and sand encroachment. The Sahara Desert alone covers almost 40 percent of the territory, and fertile areas are increasingly at risk. The implications are not only environmental but also social and economic: degraded land undermines agricultural productivity, fuels rural poverty, and accelerates migration. Recognizing the severity of the issue, Tunisia has aligned itself with international frameworks such as the United Nations Convention to Combat Desertification (UNCCD) and has introduced a National Action Plan (NAP) to mitigate the problem through integrated land management.

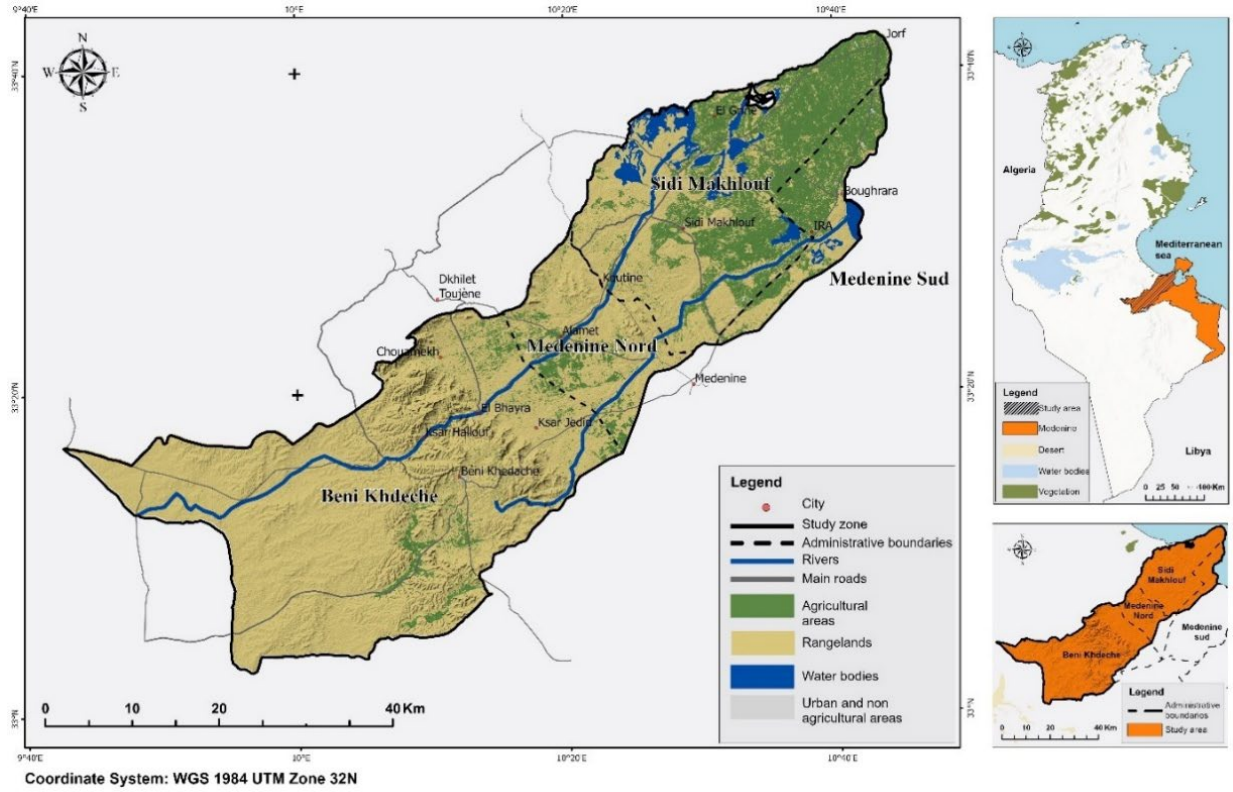
Central to Tunisia's strategy are water harvesting techniques (WHTs)—traditional practices that combine soil and water conservation with agricultural productivity. Systems such as Jessour and Tabias have been used for centuries in southern Tunisia to capture scarce rainfall, reduce erosion, and improve soil fertility. While their agronomic and hydrological benefits are well acknowledged, their contribution to land degradation mitigation has not been adequately quantified.

Recharge well

This research therefore set out to fill that gap. Its objective was to assess the sensitivity of land to desertification in the Jeffara region of Southern Tunisia and to evaluate the impact of Jessour and Tabias on reducing degradation. By integrating remote sensing, GIS-based modeling, and stakeholder knowledge, the study sought to generate a more complete picture of both the biophysical processes and the human dimensions of land degradation between 2000 and 2022.

Methodology

To achieve these aims, the research was conducted within the framework of the MONALISA project, a Horizon 2020 initiative that explores innovative solutions to prevent and reverse land degradation across Mediterranean drylands. In partnership with CIHEAM Bari and the Institut des Régions Arides de Médenine, the study focused on the Medenine governorate, a region particularly vulnerable to desertification pressures.



Geographical location of the study case

The research adopted an integrated methodology that combined top-down scientific modelling with bottom-up participatory approaches. At the heart of this framework were three scenarios designed to capture different perspectives on land degradation.

The first scenario was the baseline assessment, which applied a modified version of the Mediterranean Desertification and Land Use (MEDALUS) model. This widely used tool evaluates land degradation sensitivity through a set of indices covering climate, soil, vegetation, management, geomorphology, and socio-economic conditions. By processing spatial data from sources such as NASA, Sentinel-2, and regional agricultural maps, the model produced a detailed map of degradation sensitivity across the study area.

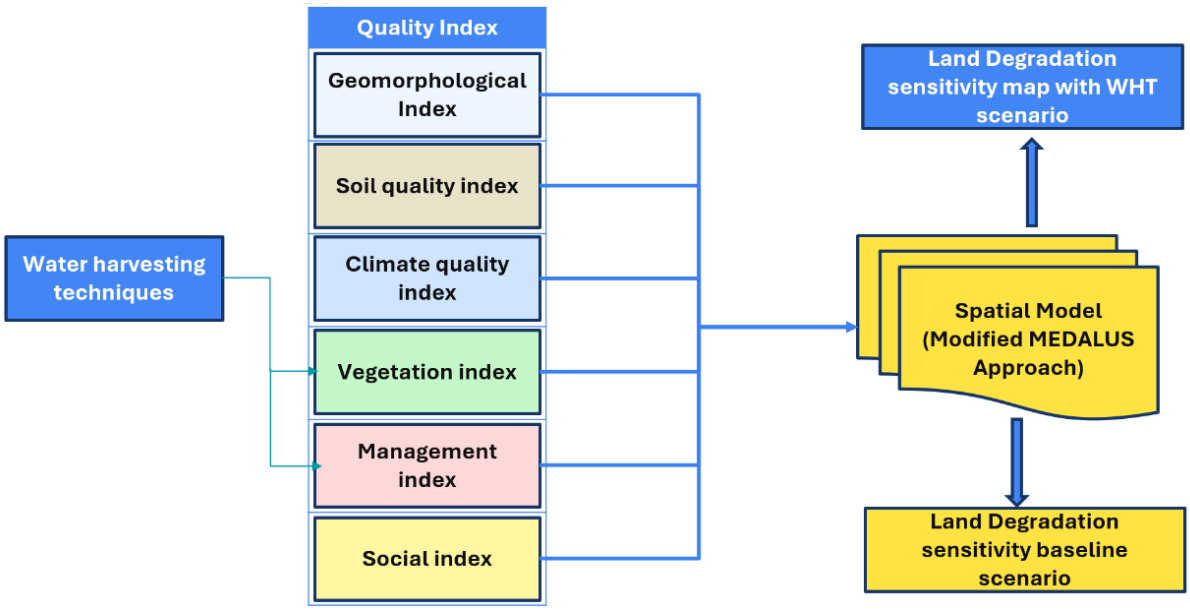


Illustration of the implementation of the WHTs Scenario

The second scenario focused on water harvesting techniques. Here, the presence of Jessour and Tabias was mapped using semi-automatic classification techniques based on satellite imagery and topographic data. Their potential impact on vegetation and management indices was then simulated, providing insight into how these structures could alter the land degradation sensitivity index if maintained and applied consistently.

Finally, the third scenario introduced a stakeholder-informed perspective. Through structured surveys and interviews, local farmers, extension services, and authorities were asked to share their views on land degradation, its drivers, and the effectiveness of WHTs. Using the Analytical Hierarchy Process (AHP), these perceptions were quantified and reintegrated into the MEDALUS model, adjusting the weight given to different indices. This participatory element ensured that the assessment was not limited to scientific data alone but also reflected the lived experiences and priorities of those most affected by degradation.

Together, these three scenarios provided a holistic implementation strategy. The first grounded the research in objective, spatially explicit data; the second evaluated the potential of traditional practices to alter outcomes; and the third ensured that local knowledge and perceptions were fully integrated into the final analysis.

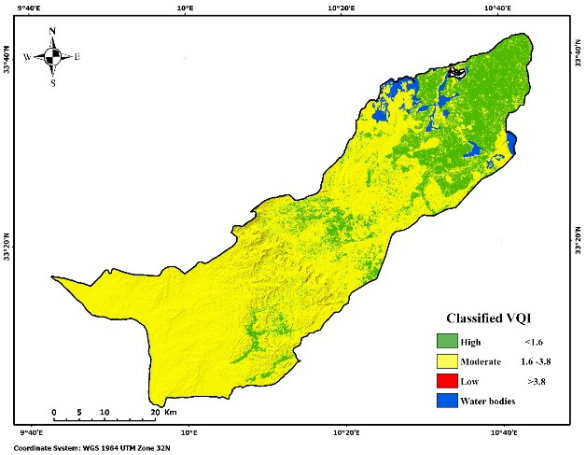
Main findings and conclusions

The findings of this research reveal the complexity of land degradation in the Jeffara region and the multiple ways in which both natural and human factors interact to shape it. In the baseline scenario, the results showed that degradation is widespread and severe across the study area. More than 99 percent of the land was classified within the critical sensitivity categories, underscoring the precarious state of local ecosystems. The most degraded zones, marked as “Critical 3,” accounted for almost a quarter of the total area and were concentrated around the Matmata Mountains, the desert margins, mining zones, and bare lands. By contrast, olive orchards emerged as somewhat more resilient. Their drought-resistant nature and relatively better management practices enabled them to maintain a lower sensitivity, highlighting the importance of crop selection and land use in mitigating degradation pressures.

The area, expressed in absolute and percentage, of the LDSI

Class	Area (Km^2)	Area (%)
Potential	-	-
Fragile 1	-	-
Fragile 2	0.27	0.01%
Fragile 3	13.23	0.60%
Critical 1	124.46	5.64%
Critical 2	1 555.85	70.46%
Critical 3	514.32	23.29%

When shifting to the water harvesting techniques (WHTs) scenario, a different picture emerged. The mapping exercise made it possible to trace the presence of Jessour and Tabias, with Jessour typically located in steep valleys and Tabias more common in foothills and flatter terrain. Their implementation showed a tangible improvement in land quality. Vegetation quality, for example, improved considerably, with high-quality zones increasing from about 22 percent in the baseline to nearly 38 percent under the WHTs scenario. Similarly, management quality also improved in the modeled conditions, reflecting the beneficial role of these techniques in stabilizing soil, enhancing water retention, and sustaining agricultural practices. However, this optimistic outcome was tempered by a crucial caveat: the scenario assumed that all structures were well maintained. Field observations suggested that abandoned or poorly managed systems were far less effective, revealing that the success of WHTs is highly dependent on long-term care and investment.



Spatial representation of the vegetation quality

The stakeholder-informed scenario further enriched the picture by integrating the perspectives of local farmers, extension workers, and authorities. From their point of view, the most pressing drivers of land degradation were reduced water availability, soil erosion, and vegetation loss, each contributing significantly to the crisis. Migration emerged as a particularly complex factor: while it was seen as a consequence of land degradation, it also reinforced the problem by leading to land abandonment and the weakening of traditional land management systems. Stakeholders gave the greatest importance to vegetation quality, viewing it as the clearest indicator of land health, whereas soil characteristics were considered less decisive. When these perceptions were integrated into the model, the share of land categorized as highly critical expanded by about sixteen percent, especially in the western foothills of the Matmata Mountains. This adjustment illustrated the value of including local knowledge, which captured aspects of degradation not fully reflected in the scientific indices alone.

Land degradation index weights

Index	Weight
Slope	0.153846
Soil	0.149321
Climate	0.171946
Vegetation	0.19457
Management	0.171946
Socioeconomic	0.158371

Taken together, the results point to a layered and interconnected reality. Land degradation in Jeffara is not simply the outcome of physical processes such as erosion or aridity, but also of socio-economic pressures, institutional weaknesses, and historical land-use choices. Water harvesting techniques clearly offer a pathway toward resilience, but their promise can only be realized if they are adequately maintained and embedded within a broader framework of community participation and institutional support. In this sense, the study demonstrates the importance of combining top-down modelling with bottom-up engagement, producing a more accurate and socially grounded understanding of land degradation sensitivity.

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Assessing the social and economic impact of agricultural cooperatives on rural women in Jendouba region, Tunisia

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Introduction

The research was carried out in the Jendouba governorate of northwest Tunisia, a region where rural poverty, unemployment, and gender inequality intersect to create difficult living conditions for women. Although women represent nearly 58 percent of the agricultural labor force, their earnings are typically half those of men, and they often struggle to access land, credit, training, and decision-making positions. Agriculture remains central to the local economy, but the sector is underutilized, largely because women—who are vital contributors—are restricted by structural barriers.

Average time spent on daily activities by men and women

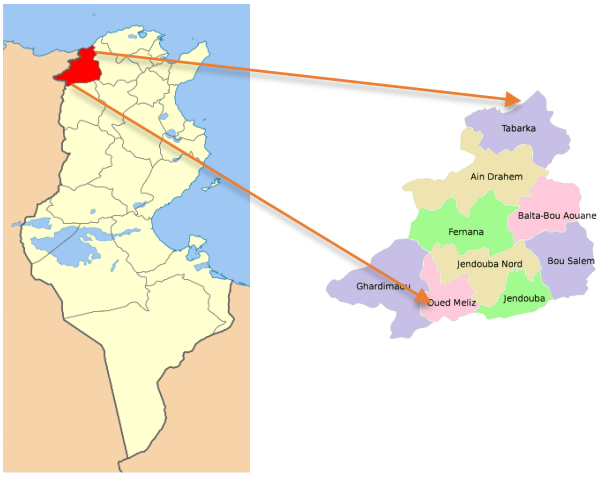
	Agricultural activities related to livestock (hour/day)	Agricultural activities related to crops (hour/day)	Other economic activities (hour/day)	Housekeeping (hour/day)	Taking care of young and old people (hour/day)	Average time spent on activities (hour/day)
♂	3.45	2.06	1.97	0.02	0.26	7.76
♀	3.51	1.13	0.54	3.52	1.87	10.58

In recent years, agricultural cooperatives, and particularly *Sociétés Mutuelles de Services Agricoles* (SMSAs), have emerged as important institutions for addressing these challenges. They allow women to pool resources, gain access to markets, benefit from collective bargaining, and participate in training activities. Cooperatives are also expected to provide platforms for social empowerment by encouraging participation in decision-making, leadership roles, and community development.

The study at hand was motivated by the recognition that, despite their potential, the real impact of these cooperatives on rural women's lives had not been sufficiently evaluated. The research therefore sets out with three main objectives. First, it sought to measure the socio-economic effects of cooperative membership on rural women, especially in terms of income stability, financial independence, and influence in household and community decisions. Second, it aimed to identify the determinants of participation, asking why some women join cooperatives while others remain outside them. Finally, the study attempted to highlight the barriers that still prevent women from fully benefiting from cooperative membership. By doing so, it intended to provide evidence-based recommendations for strengthening cooperatives as vehicles for women's empowerment and rural development.

Methodology

To achieve these aims, the study was conducted in two cooperatives located in Jendouba. The first, Fontaines Bénies, was established in 2019 in the Babouch area of Ain Draham. With 91 women members, it specializes in the distillation of aromatic plants, the production of honey, cheese, and dairy products, and the preservation of traditional ecological knowledge. The second cooperative, Lellassen Khmir, was founded in 2021 in Fernana and brings together 57 members who produce essential oils, honey, and traditional Tunisian foodstuffs such as Mloukhia and Harissa. These two cases were chosen because of their strong participation of women, their geographical differences, and their accessibility for fieldwork.



Geographical Location of Babouch and Fernena region

Field surveys constituted the backbone of data collection. They were conducted in November 2024 during open days organized by the project team to raise awareness of the cooperatives and encourage membership. This setting made it possible to interview both cooperative members and non-members under similar conditions. In Babouch, 29 cooperative members and 24 non-members were surveyed, while in Fernana, 30 members and 21 non-members participated. The survey questionnaire had been tested beforehand with a small pilot group to ensure clarity and to avoid fatigue or misinterpretation.

Field survey during the open day

The study adopted both descriptive and inferential methods of analysis. It began with descriptive statistics to map the socio-economic profile of the participants, followed by comparative analyses between members and non-members. To move beyond surface-level differences, the research employed chi-square tests to assess statistical significance in areas such as income growth, access to training, and decision-making power. Regression models were also applied—linear, binary logistic, and ordinal logistic—to isolate the variables most strongly associated with empowerment outcomes. Finally, a Multiple Correspondence Analysis was conducted to visualize the complex interplay of social and economic factors influencing women's empowerment.

By combining these approaches, the research was able not only to compare cooperative members with non-members, but also to uncover the underlying determinants of empowerment. This comprehensive methodology provided a nuanced picture of how cooperatives operate within the realities of rural Tunisia.

Main findings and conclusions

The findings paint a mixed but overall positive picture of the role of cooperatives in transforming women's lives. In terms of socio-demographic profiles, members were mainly middle-aged women between 25 and 59 years old. Non-members tended to include more very young women, as well as older individuals, suggesting that both ends of the age spectrum face greater barriers to integration. Education influenced membership

differently across the two sites: in Fernana, better-educated women were more likely to join, while in Ain Draham the link was weaker, hinting at local variations in social norms and opportunities.

Determinants of Economic Outcomes: Regression Analysis of Economic Satisfaction, Financial Independence and Income Growth

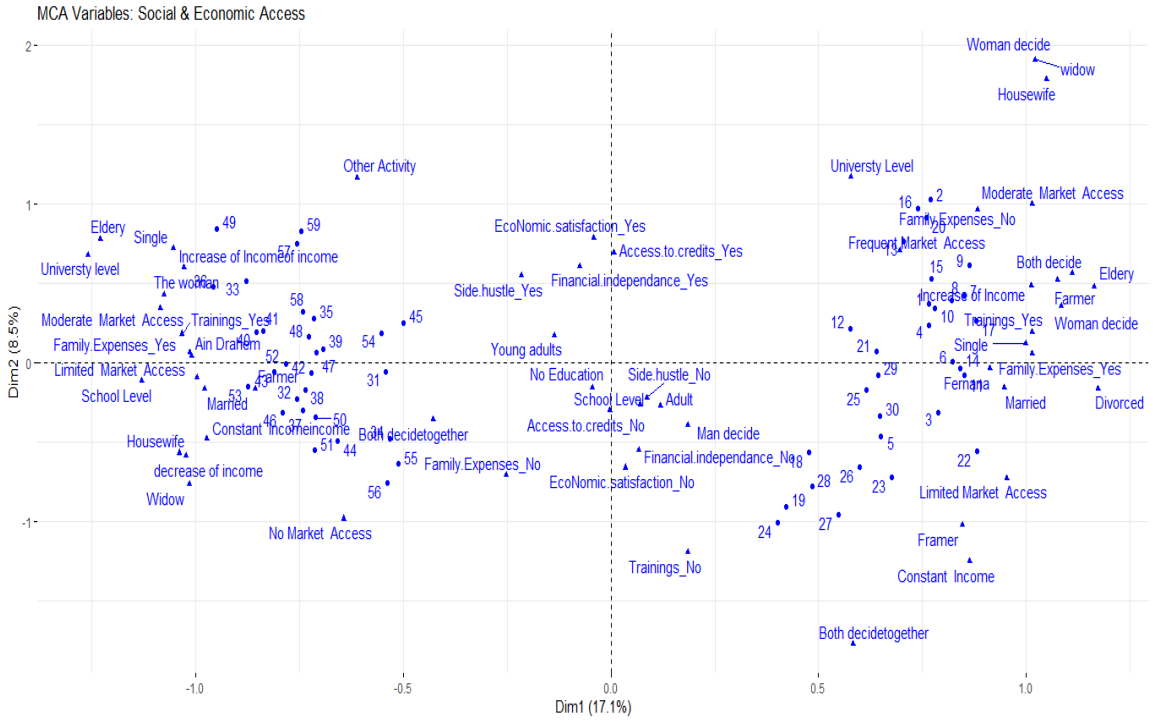
Studied Variable	Economic Satisfaction		Financial Independence		Income Growth	
	Coeff	*Sig.*	*Coeff*	*Sig.*	*Coeff*	*Sig.*
Marital Status	1.476	0.060*	-0.475	0.571	1.210	0.086*
Decision Making	1.199	0.074*	1.300	0.068*	0.899	0.153
Trainings	2.493	0.011**	4.372	0.008**	2.329	0.006**
Access to credits	1.190	0.109	1.493	0.092*	1.103	0.080*
Access to market	1.779	0.001**	2.410	0.001**	1.656	0.001**

Notes: ** significant at 5 %, * significant at 10 %.
Number of obs. = 106
Prob > chi2 = .0000

Economically, membership was clearly advantageous. A large majority of cooperative members reported increases in their income after joining, while many non-members experienced stagnation or even decline. In Babouch, for example, 78 percent of members described positive income growth, compared to widespread dissatisfaction among non-members. In Fernana, similar trends were observed, with members considerably more likely to have seen their earnings improve. Financial independence was also significantly greater among members, many of whom could contribute to household expenses and manage resources without relying entirely on their husbands or families. However, access to credit remained limited, even for members. While women in Fontaines Bénies were more likely than non-members to secure loans, the overall proportion was still low, and in Lellassen Khmir the difference was negligible.

Social empowerment showed equally encouraging patterns. Cooperative members were more involved in household decision-making, and in many cases, they gained a voice in matters traditionally reserved for men. In Fontaines Bénies, over a third of members reported having genuine influence in family decisions, nearly double the number of non-members. Access to training emerged as another major benefit. Almost all cooperative members had participated in training sessions on agriculture, business management, or financial literacy, whereas such opportunities were rare among non-members. These sessions did not only build technical skills but also fostered confidence and solidarity among women.

Statistical analysis confirmed that training and market access were the most powerful determinants of empowerment. Women who received training and who were able to sell products regularly in markets were far more likely to report higher income, greater economic satisfaction, and stronger autonomy. Marital status also mattered to some degree: married women were slightly more likely to experience income growth, possibly because of more stable family resources. Credit access, by contrast, showed only a partial effect, boosting income but not always translating into broader satisfaction or autonomy.



MCA analysis of social and economic variables

Despite these advances, the study also highlighted persistent challenges. Poor infrastructure, high costs of inputs, and limited financial services continued to constrain women's capacity to benefit from cooperatives. Social and cultural norms remained a barrier as well, especially in Fernana, where women's domestic responsibilities and conservative traditions often limited their participation in training or meetings. The isolation of rural areas compounded these difficulties, making market access particularly difficult.

In sum, the research showed that cooperatives have genuine potential to improve women's lives, particularly by raising incomes, strengthening independence, and creating platforms for training and decision-making. Yet, their transformative power remains incomplete. Without better infrastructure, wider financial inclusion, and policies that explicitly address gender norms, cooperatives cannot fully overcome the systemic inequalities faced by rural women in Tunisia.

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