PREPARING THE NEXT GENERATION OF PROFESSIONALS FOR RESILIENCE IN AGROECOSYSTEMS

The research of the "SARe Master of Science" students
A.Y. 2022/2024








Edited by: Lamberto Lamberti, Philipp Debs & Eustachio Dubla

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Edited by:

Lamberto Lamberti: CIHEAM Bari Scientific Administrator – Coordinator of the Sustainable Agroecosystems and Resilience (SARe) Master of Science.
e-mail: lamberti@iamb.it

Philipp Debs: CIHEAM Bari Agent – SARe Scientific Tutor
e-mail: debs@iamb.it

Eustachio Dubla: CIHEAM Bari Scientific Administrator – Communication office
e-mail: dubla@iamb.it

CIHEAM Bari

Director: Maurizio RAELI
Via Ceglie 9, 70010 Valenzano – Bari
Tel.: (+39) 080 4606 111
e-mail: iamdir@iamb.it
www.iamb.ciheam.org

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 2022/2024. They were 10, representing the following countries: Algeria, Egypt, Ethiopia, Kenya, Lebanon, Malawi, Morocco, Serbia, 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.

Name	Country	Research title
Salima ALOUI	Algeria	Implementation of Agroecological living lab for defining local and sustainable food systems: the case study of DziriALL in Algeria
Muhammad Atef Ahmed HAMMAD	Egypt	Assessing the effects of regenerative agricultural practices on soil quality: the case study of El-Sharkia governorate, Egypt
Achamyeleh Anteneh KASSAHUN	Ethiopia	Diversity, management, and importance of woody tree species in agroforestry practices in the unexplored areas of North-western Ethiopia
Moses MAHUGU	Kenya	Engaging pastoralists in irrigated agriculture in Kenya: learning lessons from interventions in Turkana North & Kibish sub-County

[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

Maroun BOU MATAR	Lebanon	Assessing the entrepreneurial resilience in the agri-food sector in Mount-Lebanon: exploring challenges and coping strategies
Fatsani Damson CHIMUTU	Malawi	Farmers' perceptions of land degradation and management measures – a case study of Chisazima and Kaunda villages in Kasungu, Malawi
Fatima-Zahra FAHIM	Morocco	Socio-economic dynamics of carob farming in High Atlas: an explorative study in Azilal province
Jovana ASKRABIC	Serbia	On- and off-site impacts of different land management practices related to soil health and flood control within small watersheds of Celinac Municipality in Bosnia and Herzegovina
Amina KHADER	Tunisia	Challenges, barriers, and determinants of farmers' adoption of agroecological practices in Tunisia: a case study of Hamam Biadha and Elles Tunisia

Implementation of agroecological living lab for defining local and sustainable food systems: the case study of DziriALL in Algeria

Author: Salima ALOUI (Algeria)

Supervisors: B. Rahmoune (ENSA, Algeria), C. Ciaccia (CREA, Italy),
P. Debs (CIHEAM Bari, Italy)

What were the research background and objective?

The global food system is at a crossroad. The dominant industrial agricultural model relies on high external inputs, monocultures, standard varieties/breeds and global trade to meet rising population demand. However, this input-intensive conventional system faces growing economic, environmental, and social contradictions that challenge its long-term sustainability.

Agroecology has emerged as a promising approach for a transition of conventional agriculture toward more locally adapted, sustainable systems. By diversifying farms and rebuilding ecological functions, agroecology promotes food sovereignty, environmental stewardship, and social justice. Community participation and multi-stakeholders' engagement are important principles for guiding an agroecological transition.

Agroecological Living labs (ALL) are considered an important mechanism that can drive agroecological transition in specific territory. ALL is an open innovative ecosystem that uses real-life test environments, aimed to facilitate experimentation and innovation, bringing together various stakeholders to co-create, explore, experiment, and evaluate new ideas, scenarios, processes, systems, concepts, or products in multiple real-life contexts. Agroecological oriented living labs provide means to test innovative practices on-farm, while engaging farmers, researchers, and other actors, building upon agroecological principles.

In the European project "Agroecology Living Labs to promote robust and resilient Organic production systems - CORE Organic (2021-2024)", ALLs provide a model to test innovations co-developed and co-implemented with farmers, making them a valuable tool alongside research infrastructures for supporting agroecological transitions. Through this project, the living labs established in different locations are places for knowledge exchange and on-farm trials of diversification strategies.

Location of the Living Lab in the ALL-Organic Project: Delineation of the Miliana Territory for the Algerian Living Lab (DziriALL) and Identification of Participating Farmers

Within the project, in Algeria, the National Higher School of Agronomy (ENSA) is going to propose the agroecological living lab, called DziriALL, where Dziri is the original name of Algeria in Arabic language. It falls in Miliana, a municipality located in northwestern Algeria, in the Atlas Mountains, at an elevation of

approximately 800 meters above sea level. The surrounding region is primarily agricultural, known for its cultivation of olive groves, vineyards, almonds, and orchards on the mountainous terrain.

The process of DziriALL implementation needs a preliminary step for assessing farming systems in the area and identifying agroecological topics and challenges around which local stakeholders can be mobilized and work together. It needs identification of the location and its characteristics, priorities of stakeholders and research.

Under this framework the present study aimed at understanding the main features of the agroecosystem in Miliana that can link local stakeholders on an agroecological transition.

Specifically, it aimed at:

- identifying the main agroecological features to work on in the ALL.
- understanding the attitudes of farmers to be part of LLs.
- identifying the main challenges for the ALL establishment.

How was the research implemented?

A qualitative approach was chosen to gain an understanding of stakeholder perspectives, experiences, priorities and needs for an ALL establishment; and on factors influencing the adoption of agroecological practices by farmers. For the purpose 10 semi-structured interviews were conducted in the field to interview key farmers, with open-ended questions to understand agricultural practices, challenges and views on agroecology.

A questionnaire was administered with 21 respondents representing the stakeholders involved in DziriALL, to gather information about local farming systems, challenges and priorities among the stakeholders for transitioning to more sustainable agriculture. A purposeful sampling approach was used to identify respondents representing farmers and other stakeholder groups (researchers, officers, practitioners from research local institutions non-profit organizations).

Qualitative data collection methods

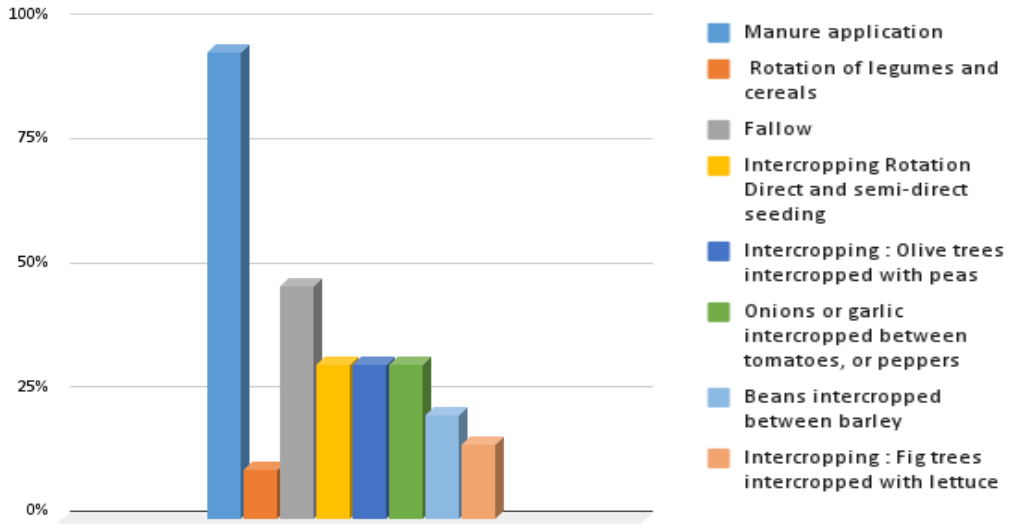
Number	Key informant	Data Collection	Location
10	Farmers	Interviews/Focus group/Farm visits	Miliana region
11	Researcher, Technician, Non-profit organisation	Interviews/Focus group	Miliana region / Algiers (ENSA)

Finally, two focus groups were carried out with researchers and farmers mainly centred on topics of crop diversification and soil fertility management, that were priorities that came out from preliminary research steps.

Data collection occurred from November 2023 to January 2024.

What were the main findings?

From the discussion with Miliana farmers and questionnaire responses it resulted that their main interests are on cereal (wheat and barley mainly), fruit crop production and vegetables. This diversity allows farmers to balance food, feed and cash needs, and demonstrates great potential for Miliana living lab to foster multi-actor innovation through an integrated system approach. Farmers in the region practice already some agroecological practices. Mostly apply manure for soil fertility or use fallow to regenerate soil fertility. Intercropping is also diffused, such as olives with peas, onions or garlic with tomatoes or peppers, barley with beans. The purpose is to increase land productivity, enhance resource use efficiency and control pests.



Current Farming Practices in the Miliana Region

Regarding the main challenges faced by farmers, they highlighted that the most important is the heavy reliance of their livelihoods on rain-fed agriculture, that leaves producers highly vulnerable to fluctuations in weather and to the increasingly frequent droughts. This threatens food security and livelihoods for local people, and stimulates migration flows from rural areas.

The word clouds from the Miliana interviews provided insight into farmer priorities in the region for an agroecological transition. Key themes were the need of new markets, local research activities, working with farmers, developing organic production, have access to knowledge and equipment, preserve and valorise traditional practices.

Word cloud of stakeholder responses from the Dziri Agroecology Living Lab formative research

Research priorities for the ALL that emerged through focus groups, were the development of practical solutions on soil fertility management. It was underscored the importance of setting on-farm trials on intercropping, green manuring, composting, to improve biodiversity and soil nutrient cycling.

Regarding the challenges that stakeholders attribute to the process of establishing an ALL, it was highlighted that it is of key importance to base it on inclusiveness, building on local demand and capacities. The promotion of farmers' participation and networking was also identified as a key condition, emphasizing that former top-down policies have decreased the trust of farmers in government initiatives. Finally, it emerged the need for ALL activation to have financial capacities to mobilize actors and ensure a productive and efficient participation.

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Assessing the effects of regenerative agricultural practices on soil quality: a case study of El-Sharkia governorate, Egypt

Author: Muhammad Atef Ahmed HAMMAD (Egypt)

Supervisors: A. Sabahy (Heliopolis University, Egypt), P. Zdruli (CIHEAM Bari, Italy)

What were the research background and objective?

The effects of conventional agriculture, based on monocropping, intensive tillage and use of chemicals, is frequently associated to harmful effects on soil properties and field productivity. The term "Regenerative Agriculture" (RA) has recently started to gain traction among practitioners and scholars to address the pressing issue of keeping soil healthy and productive. The Rodale Institute in California defines regenerative farming as a holistic, long-term approach aimed at maximizing food production while minimizing resource use, revitalizing the soil instead of depleting it. RA is founded on several principles and a range of practices that improve soil properties and functions.

Regenerative agriculture principles, practices, and purported benefits and mechanisms to improve soil health

RA Principles	RA Practices	RA Merits	Microbial Mechanisms
• Minimize soil disturbance • Keep soil covered • Keep living roots in soil year round • Encourage diversity • Integrate Livestock	• No/minimum tillage • Stubble retention • Diverse crop rotations • Multispecies cover crops • Intercropping • Composting and use bio stimulants • Rotational grazing • Reduce synthetic inputs	• Improved soil through Increased soil carbon Improve microbial functions and associated nutrient cycling Improved soil moisture Improve resilience to pests and diseases • Nutrient rich food • Reduced greenhouse gas emission	• Liquid carbon pathway • Improved uptake of water and minerals • Enhanced soil aggregation, plant growth and photosynthesis

In Egypt, a large area of agricultural land is under conventional agriculture based on an intensive use of soil resources. Soil degradation is a big issue and many farmers, most of them smallholders, are impacted by this problem. RA is still an approach not very diffused except for specific cases. SEKEM is one of these cases, being a company engaged in the last decades in biodynamic agriculture that has developed a big network of farmers using regenerating practices.

The present research had the main objective to study the effects of regenerative agriculture practices on soil health and quality in a study area where RA practices are applied, including also a socio-economic analysis to understand RA farmers' profiles. The focus was on a set of practices used by farmers as part of the SEKEM network.

How was the research implemented?

The study was conducted in the farms of SEKEM, in Belbeis City, El-Sharkia Governorate - Egypt. The climate in the study area is typically a desert climate, with no rainfall during the year except in winter, which receives little rainfall.

Farms were selected according to specific criteria: similarity of climate conditions and soil typologies, cultivated crops, and adoption of regenerating practices (agroforestry, intercropping, crop rotation, cover crops, no-till and minimum tillage). All the farms had access to groundwater and used drip irrigation systems.

Soil samples collection was finalized from fields under regenerative practices and conventional ones, for comparison. These were analysed chemically, physically, and microbiologically. Soil parameters were considered such as organic matter, organic carbon, field capacity, electrical conductivity (EC), pH, total count bacteria (T.C.B), total count fungi (T.C.F), available nitrogen, phosphorus, and potassium.



Selected soil samples, practices, farm size, and crop seasonality

Soil number	Farm Size (ha)	Crops
Conventional 1	0.56	Peanut *(Arachis hypogaea),* Wheat (*Triticum sp) and* Alfalfa (*Medicago sp*)
Conventional 2	0.15	Maize (*Zea mays),* Wheat *(Triticum sp) and* Soybean *(Glycine max*)
Conventional 3	1.7	Wheat (*Triticum sp*), Alfalfa (*Medicago sp*), Fava beans (*Vicia faba*)
Conventional 4	0.5	Maize (*Zea mays*), Green beans (*Phaseolus vulgaris*), and Wheat (*Triticum sp*)
5- Biodynamic (DOC Trial)	1.5	**Winter Season**: Wheat (Triticum sp), Potatoes (Solanum tuberosum), Fava beans (Vicia faba); **Summer Season**: Soybean *(Glycine max*), Zucchini *(Cucurbita pepo*), Cowpea (*Vigna unguiculata),* Maize (*Zea mays), and Tomato* (*Solanum lycopersicum*)
6-Cover Cropping	0.25	Alfalfa (*Medicago Lotus*)
7-Crop Rotation	2	Green beans (*Phaseolus vulgaris*), Onions (*Allium cepa*), Wheat (*Triticum sp*), and Beet (*Beta vulgaris*), Maize (*Zea mays*), and Sesame (*Sesamum indicum*),
8- Agroforestry	3.5	Annona (*Annona squamosal)*, Chaste tree *(Vitex agnus-castus),* Mulberries *(Morus sp),* Moringa *(Moringa oleifera),* Mango (*Mangifera indica),* Jojoba *(Simmondsia chinensis),* Buckthorn *(Rhamnus)* and Banana (*Musa sp*)

The research included also a small survey, filling in a questionnaire with 35 farmers adopting RA practices, designed to gather views of farmers' profiles. All respondents were selected from the database of SEKEM.



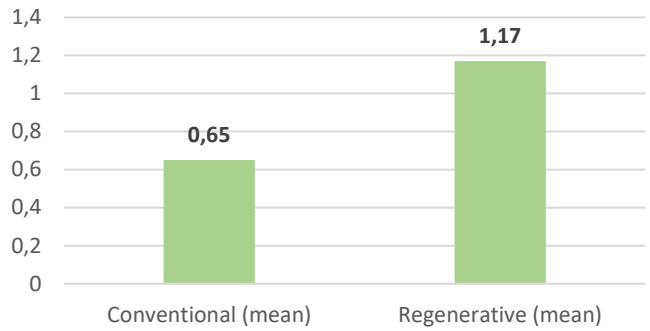
What were the main findings?

Soil analysis showed that most of parameters identified to evaluate soil quality had better values in samples from fields under RA practices. Significant differences were found for pH, OM, OC, T.C.B. and T.C.F. that indicate a healthy and active status of soils. In addition, the content of potassium was always higher in RA soil samples while values of nitrogen, phosphorus, field capacity and EC did not give significant differences with conventional soil samples.

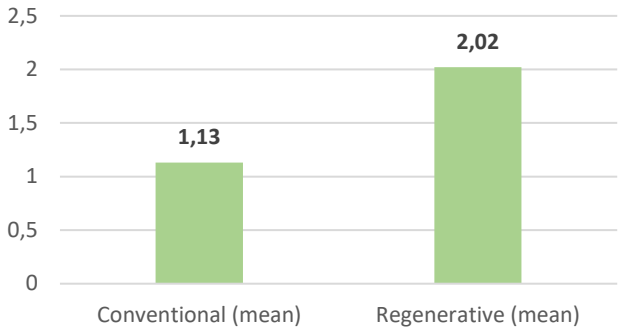
Parameter values, including the mean and standard deviation (SD), range, and significant differences (P- value) between conventional and regenerative system

Parameters	Conventional		Regenerative		P-value
	Mean ± SD	Range	Mean ± SD	Range	
Organic Matter (%)	1.13±0.49	0.64-1.8	2.02±0.22	1.8-2.30	(0.016) *
Organic Carbon %)	0.6 5±0.28	0.37-1.04	1. 17± 0.12	1.04-1.33	(0.016) *
Field capacity (%)	15.87± 2.75	13.5-19.5	17.00 ±3.16	14-21	0.611
EC (ds/m)	2.57±0.70	1.8-3.5	2.21±0.23	1.96-2.50	0.370
pH	7.97±0.20	7.71-8.2	7.43±0.18	7.20-7.65	(0.009) **
T.C.B.	$2425X10^5$±$45X10^6$	$18X10^7$-28 $X10^7$	$2275X10^6$±$73X10^7$	$15X10^8$-$30X10^8$	(0.002) **
T.C.F.	$5X10^4$± 8164.96	$4X10^4$-$6X10^4$	2512500±2061704	$5X10^5$-$5X10^6$	(0.026) *
Nitrogen (mg/kg)	95.40±5.09	90-102	90.00±11.43	76-102	0.455
Phosphorus(mg/kg)	6.70±1.33	5.12-8.34	6.35±1.14	5.56-7.98	0.705
Potassium (mg/kg)	158.25±17.93	152-176	266±28.80	234-303	(0.001) **
Values with (*) are significant at (p<0.05); Values with (**) are significant at (p<0.01)					

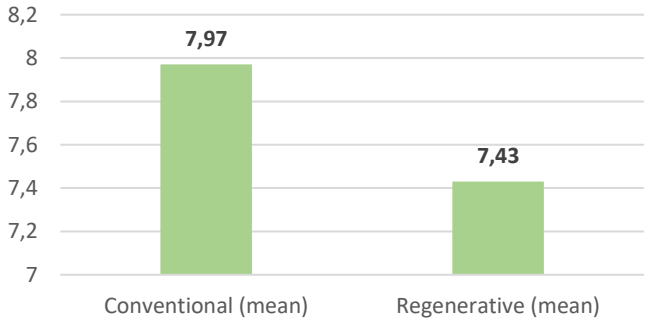
Organic Carbon %



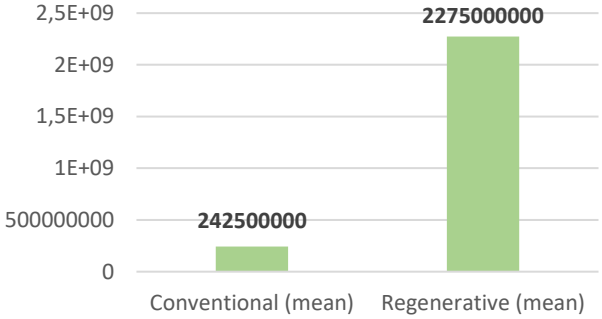
Organic Matter %



pH

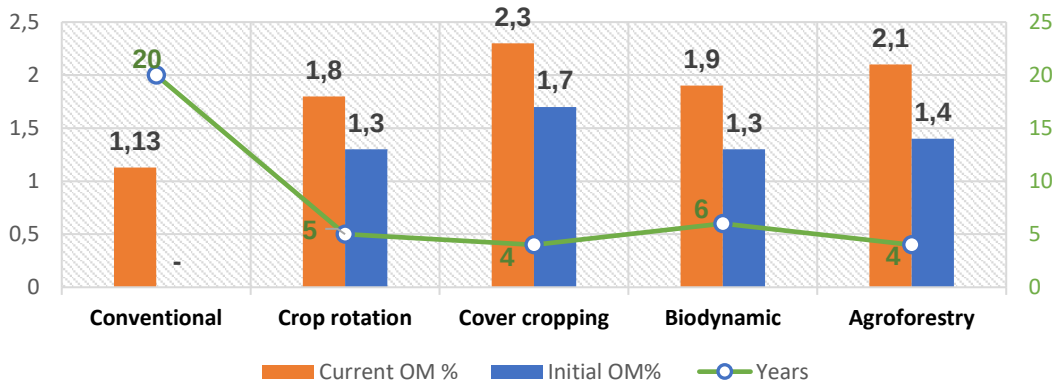


TCB CFU/mL

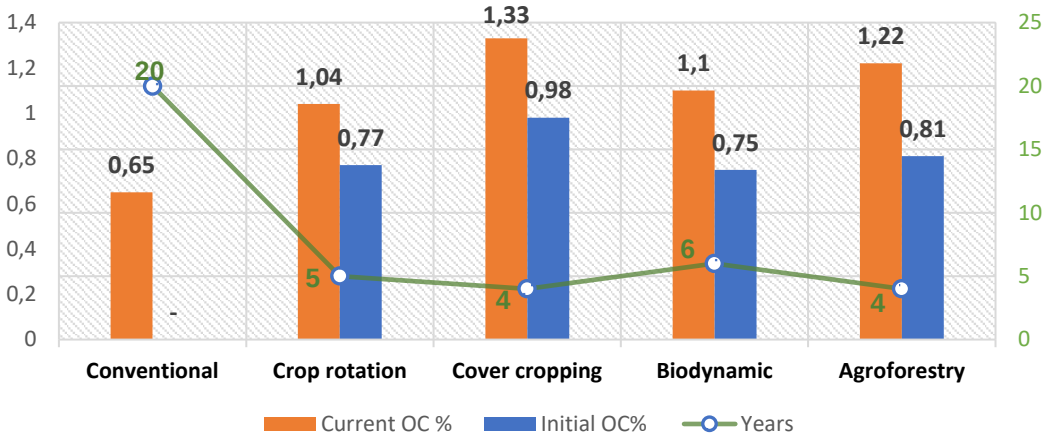


Comparisons with previously collected data from the same fields showed that parameters like OM, OC, and pH, have been significantly improved over the years, apparently in relation to the application of these practices compared to conventional.

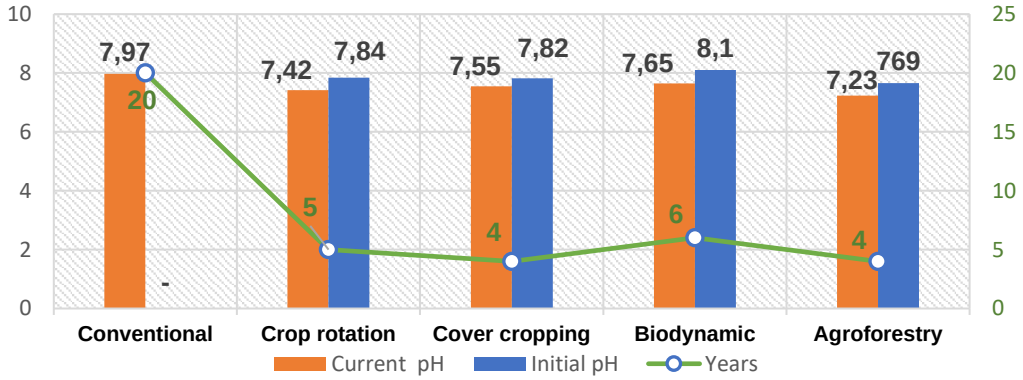
Soil organic matter and years of applying these practices from the beginning in 2020 (Initial values) until current OM in 2023



Soil organic carbon and years of applying these practices from the beginning in 2020 (Initial values) until current OC in 2023



pH values and years of applying these practices from the beginning in 2020 (initial values) until current pH in 2023



In addition, the visual and manual assessment confirmed the presence of better soil aggregates associated with RA practices.

The survey implemented with the 35 farmers of the SEKEM network identified the main features of the farmers implementing the RA practices. They were mainly over 30 years old, with the majority over their 60's, and well experienced in farming (more than 90% with at least 10 years). They are all smallholders with around 43% with 1 to 7 acres of farmland and more than 50% with above 7 acres. Around 45% hold a university degree and 37% have a primary or secondary school diploma.

Regarding the adoption of RA practices, almost all farmers use compost for soil fertility management, and most of them use minimum tillage, crop rotation, intercropping, and agroforestry. On the opposite, the interviewed farmers do not use cover crops

Descriptive statistics for variables influencing the adoption of regenerative practices

Variables		Frequency (n=35)	Percentage
Age	Young (Less than 30 years)	3	8.6%
	Middle aged (31 to 50)	11	31.4%
	Old (above 51 years)	21	60%
Gender	Male	35	100%
	Female	-	Zero
Marital status	Marriage	33	94.3%
	Unmarried	2	5.7%
Education level	Illiterate	6	17.1%
	Primary	7	20%
	Secondary	6	17.1%
	University	16	45.7%
Farming experience	Less than 10	2	5.7%
	1-20 years	11	31.4%
	More than 20 years	22	62.9%
Regenerative Farming experience	Up to 3 years	14	42.9%
	4-6 years	7	20%
	6-8 years	2	5.7%
	More than 8 years	11	31.4%
Farm size	Less than 1 acre	2	5.7%
	1.1 to 7 acres	15	42.9%
	More than 7	18	51.4
Irrigation system	Drip	15	42.9%
	Floods	17	48.6%
	Both	3	8.6%
On- farm activities	Crop farming	14	40%
	Crop farming and animal production	21	60%
Off-farm income	Yes	13	37.1%
	No	22	62.9%

Regenerative agriculture practices adopted by farmers in the study area

Regenerative practices	Percentage	(n=35 farms)
1- Intercropping	51.4%	18
2- Minimum tillage	68.6%	24
3- Cover crops	zero	-
4- Integrated livestock	62.9%	22
5- Crop rotation	60%	21
6- Use of compost	97.1%	34
7- Agroforestry	37.1%	13

In conclusion, the research findings indicate how regenerative practices may improve significantly the soil features. Significant evidence was collected for practices such as cover cropping, crop rotation, minimum tillage, composting, and agroforestry.

However, to gain a deeper understanding of the effects of these regenerative farming practices on enhancing soil quality, it is recommended to conduct longer-term field studies and investigate their impacts on soil parameters for each practice, separately. Soil analysis should be conducted on the soil that has undergone cover cropping and agroforestry (for their superiority in most soil parameters) for the next three years to assess the changes in organic matter, pH, and field capacity, considering the measurements mentioned in this study.

Regarding social aspects, the study highlighted that farmers adopting these practices are most smallholders, with different ages and education, who got significant experience and capacities in the use of RA practices. It appears that their motivations for farming in a more ecological way depend on the existence of SEKEM, which takes care of capacity development and market access. This emphasizes the role in Egypt of third actors in promoting more sustainable agriculture, able to network with farmers, providing them with several services and interest in their product purchasing.

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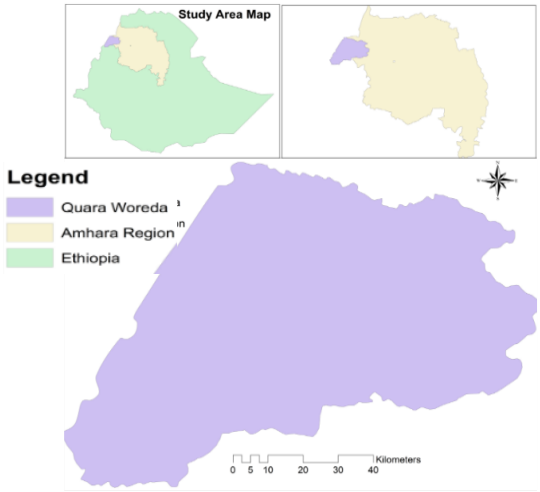
Diversity, management, and importance of woody tree species in agroforestry practices in the unexplored areas of North-western Ethiopia

Author: Achamyeleh Anteneh KASSAHUN (Ethiopia)

Supervisors: D. Fikir (University of Gondar, Ethiopia), G. Calabrese (CIHEAM Bari, Italy)

What were the research background and objective?

Agroforestry is about combining agriculture and forestry, to provide benefits for both crops and livestock. It has been often described as an ideal, ecologically, and economically suitable land-use system able to increase agricultural production and enhance soil fertility. In Africa, farmers have traditionally practiced agroforestry since ancient times on agricultural lands and pastures. The Ethiopian agroforestry farming system is an ancient practice, farmers plant and maintain woody species on croplands for multi-purpose uses including shade, shelter, fuelwood, food, fodder, and many other products and services.



Map of the study area

Quara district, in north-western part of Ethiopia, Amhara Region, is characterised by humid mountainous areas, having high potential for agroforestry. Transitioning towards the hill of the highland part, the Ethiopian landscape changes in contrast with the lowlands and the area is characterized by a humid climate. Despite the potential significance of these highland areas, scientific attention and studies have predominantly focused on the lowlands and in the past, there has been limited exploration and research conducted in these highland humid regions, leaving significant gaps in our understanding the economic importance of woody species diversity, indigenous tree management and agroforestry productions for local populations and for their resilience. This lack of knowledge resulted in less attention of policy makers to this interesting typology of farming and to the rural development of the area.

The current study was aimed at assessing the diversity, management, and the importance of the woody species and agroforestry practices for the local populations of the Quara district of the north-western lands of Ethiopia.

How was the research implemented?

Two lowest level administrative units in Ethiopia were selected, namely “Kebeles” Daza and Wefta, based on information from informants and researchers experience and a list of resident households was obtained from the Kebele offices. A total of 140 households were selected out of 2800 households, using a simple randomised sampling, 80 from Daza and 60 from Wefta.

Two main activities were carried on:

- A woody plant inventory
- Interviews to the farmers/head of households.

The woody plant inventory aimed to gather data on species diversity, distribution, and abundance within a defined area. The data serves ecological research, conservation planning, and forestry management purposes. For woody plant inventory, a quadrat sample size of 20 m x 25 m was used for coffee shade agroforestry farms; a 40 m x 40 m quadrat was adopted for grazing land; a complete enumeration of about 30 m × 30 m was done for home garden; and 50 m × 50 m for farmland. Within the main plots, five 5 x 5 m and 2 x 2 m subplots were laid at each of the four corners and one in the middle for the purpose of assessing the saplings and seedlings respectively.

Plant inventory data were analysed using different diversity indexes.

1. Shannon diversity index $H' = -\sum_{i=1}^{s}(pi)\,[ln\,(pi)]$, Where H' = Shannon-Wiener index of species diversity, S = total number of species in forest, Pi = proportion of total abundance represented by j^{th}, and ln = natural logarithm.
2. Shannon Equitability/Evenness Index (E) was calculated

   $Species\ Evenness\ E = \frac{\mathrm{H'}}{\mathrm{Hmax}}$; $\mathrm{Hmax} = \ln \mathrm{s}$. Where, H=Shannon index, H max=maximum value of Shannon index, S = total number of species.

3. The similarity index of woody species at different sites was computed using Sorensen's Similarity Index. $Ss = \frac{2a}{(2a+b+c)}$ Where Ss = Sorensen similarity coefficient, a = the number of species common to the sample, b = the number of species in sample 1 only, and c = the number of species in sample 2 only.

In the meantime, interviews were made to farmers to collect data about their perceptions of income deriving from forestry and about labour and relevance of such activity for the household as well as about personal reasons and motivations for practicing agroforestry.

What were the main findings?

In the study area 31 woody species belonging to 20 families were identified. The *Fabaceae* family was the most diverse, represented by 5 species, followed by *Moraceae* and *Myrtaceae* represented by 3 species, and *Celastraceae*, *Rutaceae*, and *Anacardiaceae* represented by 2 species. The other 14 families were represented by a single species.

There was a notable difference in woody species diversity among various agroforestry practices in the study area. The increased diversity indexes observed in home garden may be attributed to variations in the distribution of individual plants and species richness.

Shannon diversity and Evenness of trees, saplings and seedlings of woody tree species across different land use in Agroforestry (mean ± standard error)

Type of Agroforestry	Shannon diversity index for trees species			Evenness for trees species		
	Woody tree	Saplings	Seedlings	Woody tree	Saplings	Seedlings
HG	2.33±0.094[a]	1.79±0.12[a]	1.04± 0.14[a]	0.86±0.02[a]	0.87±0.02[a]	0.75±0.04[a]
CS	0.43±0.06[b]	0.91±0.12[b]	0.84±0.11[a]	0.21±0.02[b]	0.82±0.05[a]	0.68±0.06[b]
PL	1.55±0.07[c]	0.91±0.09[c]	0.75±0.07[b]	0.94±0.01[c]	0.88±0.05[a]	0.93±0.02[b]
GL	1.74±0.08[d]	0.75±0.08[d]	0.85±0.10[a]	0.96±0.01[d]	0.91±0.02[a]	0.71±0.05[c]

Means with a different letter in a column are significantly different ($p < 0.000$)
HG = Home Garden, CS = Coffee shade, PL = Parkland, GL= Grazing land

The variety of woody species was compared with other three sites already studied by other scholars (Gedeo, southern Tigray, Woliyta). In the four sites there were almost similar numbers of species: 31 species in Quara, 24 species in the Gedeo, 32 species in southern Tigray, and 31 species in the Wolyita. In contrast, in the southern Tigray region, there was a difference of 15 woody species compared to the other sites, probably due to climatic differences, because those 15 species were mainly found in drought areas. The Wolyta zone under study had a comparable composition of woody species, about 48%.

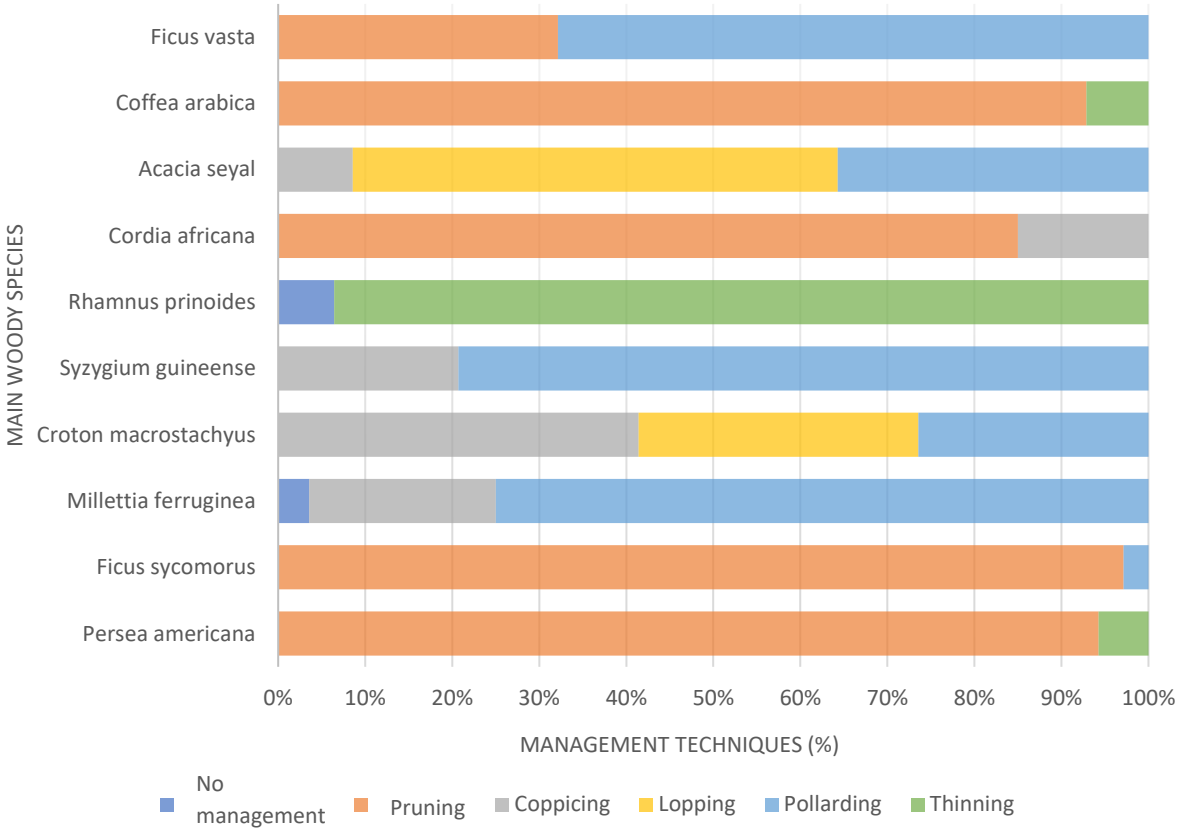
The Sorensen similarity index for the studied village showed that variation in woody species similarity ranged from 40% to 48%. The lowest similarity index value was revealed for the sites of southern Tigray and Gedo Zone (25%); this indicates a higher dissimilarity of woody species between the two sites, whereas the highest similarity index value was found in sites between Quara District and Wolyta Zone (48%). The only six species Croton macrostachyus, Cordia africana, *Coffea arabica*, *Eucalyptus camaldulensis*, *Mangifera indica*, and *Persea americana* were found to be common across the four study areas. This shows that those species had adaptability with different agroecology.

Similarity index of woody species in different study area

Similarity index				
Sites	Qura	Gedeo	Tigray	Wolyta Zone
Quara	1	0.40	0.44	0.48
Gedeo	0.4	1	0.25	0.36
S/Tigray	0.44	0.25	1	0.35
Wolyta Zone	0.48	0.36	0.35	1

From the farmers responses, it was determined that some species have a single management system and others have more than two management systems. The woody species like *Ficus sycomorus, Persea americana,* and *Coffea arabica* have the highest percentages of 97.1, 94.3, and 92.9 respectively for the pruning management system. From the survey, the woody species *Croton macrostachyus*, *Millettia ferruginea*, and *Syzygium guineense* have the highest percentages in the coppicing management system within 41.4%, 21.4%, and 20.7% respectively.

Management techniques of major woody species



The preference for woody species such as *Cordia africana, Croton macrostachyus,* and *Albizia gummifera* was determined by their ability to contribute to both ecological and economic services, as well as their versatility in fulfilling various needs as related to finding. From the listed major woody species, *Persea americana, Citrus aurantifolia, and Coffea arabica* are 100% used as food (fruit), followed by *Citrus sinensis* (89%), *Syzygium guineense* (21.4%), *Cordia africana* (17.9%), and *Ficus sycomorus* (10.7%). *Ficus sycomorus and Cordia africana* are also used as fodder (leaves) for animals, with percentages of 17.9 and 13.6 respectively. Agroforestry woody tree species significantly contribute to socio-economic development and environmental sustainability, enhancing livelihoods and agricultural resilience through their recognition and promotion.

Importance of major woody species in agroforestry practices (%)

Scientific name	Food (fruit)	Fooder (leaves)	fire wood	timber	tool handles	household utensils	shade	charcol	bee forage	medicine (roots)	flavouring (leaves)	mulch	Soil conservation
Persea americana	100	0	0	0	0	0	0	0	0	0	0	0	0
Ficus sycomorus	10.7	17.9	28.6	42.9	0	0	0	0	0	0	0	0	0
Millettia ferruginea	0	0	37.9	22.1	7.1	27.9	5	0	0	0	0	0	0
Citrus sinensis	89.3	0	0	0	0	0	0	0	0	10.7	0	0	0
Croton macrostachyus	0	0	36.4	28.6	14.3	0	15	5.7	0	0	0	0	0
Syzygium guineense	21.4	0	17.9	19.3	0	0	20	13.6	7.9	0	0	0	0
Rhamnus prinoides	0	0	8.6	0.0	0	0	0	0	0	2.1	89.3	0	0
Citrus aurantifolia	100	0	0	0.0	0	0	0	0	0	0	0	0	0
Cordia africana	17.9	13.6	7.9	35	0	0	15.7	0	2.1	0	0	3.6	4.3
Coffea arabica	100	0	0	0	0	0	0	0	0	0	0	0	0

In conclusion the study showed that:

- Agroforestry is very important for farmers and local people in Quara. Predominant woody species like, *Croton macroschuys*, *Albizia gummeiferia*, *Cordia africana*, and *Syzygium guineense* reveals significant multipurpose use that contribute to the livelihood of local households.
- Potentials for agroforestry practices development exist with indigenous trees in Quara humid area due to the high diversity of forest species and to the well-preserved knowledge of practices by farmers.
- Potentials do exist also for the development and adoption of improved ecological technologies on pruning, thinning, and pollarding of woody species, aimed at productivity and income increasing.

Conducting future research on the socio-economic dynamics of agroforestry products may help the development of forestry products value chains.

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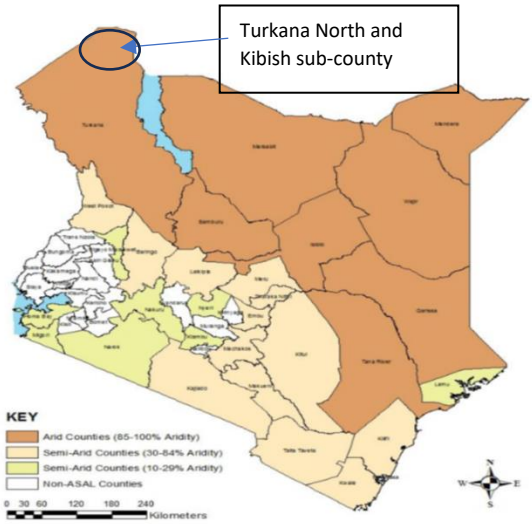
Engaging pastoralists in irrigated agriculture in Kenya: learning lessons from interventions in Turkana North & Kibish sub-County

Author: Moses MAHUGU (Kenya)

Supervisors: L. Lamberti, A. Antonelli (CIHEAM Bari, Italy)

What were the research background and objective?



Turkana North and Kibish sub-county is located in the northern region of Turkana County of Kenya and borders Ethiopia to the Northeast and South Sudan to the North. It is classified as an Arid and Semi-Arid Land (ASAL) and experiences a hot and dry season with annual rainfall ranging between 200-500mm, while the mean temperature is approximately 30.5 degrees Celsius. There are no reliable sources of surface water, such as rivers or lakes. Poor and erratic rains, frequent episodes of drought, and food insecurity characterize this region.

Pastoralism has always been the main livelihood activity of local communities, which forms an integral part of their cultural identity. Historically, the Turkana community has practiced nomadism and transhumance, as a form of adaptation to climate and environmental change, with herders moving their animals during drought to regions with water and better pastures. However, this traditional strategy has been undermined by changes in land use, installation of colonial administrative boundaries, and inter-boundary violent conflicts. In addition, climate change is increasing the intensity of episodes of drought. All these restrict free movement of herders and animals across the traditional pastoral belts. Consequently, communities lose their livestock which are the basis of their livelihood and food security.

Irrigated agriculture development has been supported for decades in Turkana region, leading to the establishment of many irrigation schemes along the banks of rivers Kerio and Turkwel. The political framework still sustains irrigation development in ASALs, as seen in Kenya's Vision 2030, and the Climate Change Adaptation Action Plan of Turkana County.

However, irrigated agriculture is not an outright alternative livelihood in Turkana North & Kibish sub-county. The surface water sources are rather temporary, and farming is only possible when groundwater is accessible. There have been interventions by Government and Non-governmental organizations that promote irrigated agriculture through the installation of boreholes and empowerment of pastoralists to practice agriculture. Various forms of irrigation are being promoted including bucket, spate, furrow and drip irrigation. However, there is an information gap on the achieved milestones and challenges faced by these interventions, which would help to drive future policies and actions.

Therefore, this study aims at understanding how irrigated agriculture is adopted by pastoralists in Turkana North and Kibish sub-county, where boreholes and simple irrigation systems have been set up within pastoral communities to facilitate agricultural development.

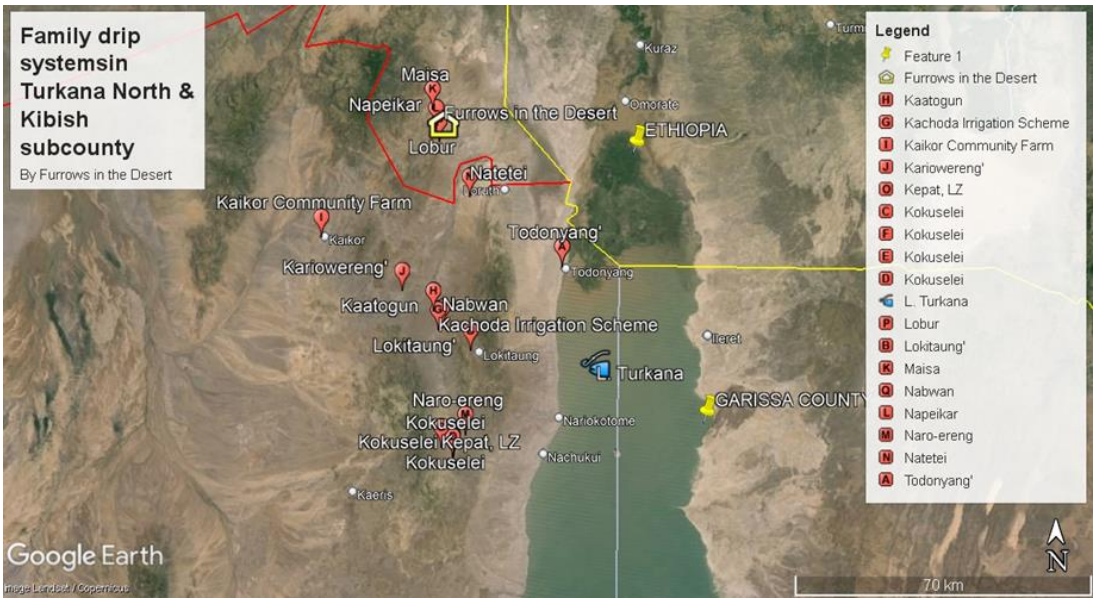
Specifically, it aims to address the following questions:

- What kind of agriculture do pastoralists practice?
- How do they get knowledge and assistance?
- What are the effects of the irrigation interventions on their livelihoods?
- What are the main challenges they are facing in irrigated agriculture?

The study focused on a territory where the project Furrows in the Desert (FiD), under the Missionary Community of Saint Paul the Apostle (MCSPA), has been supporting pastoralists to adopt irrigated crop production since 2013.
The results of this research may help organizations in the evaluation and strategic planning of activities aimed at engaging pastoralists in irrigated agriculture.

How was the research implemented?

The research adopted a case study design. It was implemented in the wards of Lake Zone (1,909 Km^2), Lapur (3,241 Km^2) and Kaikor/Kaaleng (3,834 Km^2), where FID has been present for more than 10 years. The region is classified as an ASAL, experiencing temperatures ranging between 24 and 38 degrees Celsius and a mean temperature of 30 degrees Celsius. Turkana experiences low annual rainfall ranging from 120 to 500 mm, characterized by violent storms and flash floods.



Study Area Turkana North & Kibish Sub County

A qualitative approach was used for exploring the views and experiences of 17 pastoral farmers and beneficiaries of FID interventions, from 14 different villages, were reached out for interviews and field observations. In addition, key actors including 5 officers from local institutions and 4 staff members of FID were met for in-depth interviews about irrigation development processes in the area.

The information was mainly collected using semi-structured interviews and focus groups discussions. These tools were selected for their flexibility in approach, allowing for in-depth discussions and probing into the

research questions. Field observations and document analysis were also leveraged on, to ground the findings gathered through the interviews.

All the interviews were recorded on a mobile phone, transcribed using MS Word and uploaded onto Taguette, an open-source, qualitative data analysis tool. The tool facilitated content and thematic analysis by reviewing the respondents' responses, line by line.

What were the main findings?

The study showed that, agriculture within the geographical scope is a small-scale activity practiced by pastoralists in small plots of lands of about 500 sqm, frequently in form of clusters, in proximity of a borehole as source of water for irrigation. Boreholes are installed through NGO and Government projects, with the primary aim to enhance water access to pastoral communities for their domestic and animal needs. These projects are furnished with solar-powered pumps and raised tanks for water storage.

Most of the plots are equipped with drip irrigation technologies, often referred to as the 'Family drip kit', consisting of a 1000-liter tank, raised 2 meters above the ground, and approximately 600 meters of dripline with a narrow diameter to ensure uniform irrigation in the entire plot and reduce blockage in the pipeline due to impurities. Irrigation works through gravity force. The technology is provided by FID to pastoralists and installed on their fenced plots after they have been successfully trained in irrigated crop production.

Farmers cultivate a variety of crops, for subsistence and commercial purpose. These include maize, sorghum, cow peas, leaf vegetables. Tomatoes, watermelons, squash and gourds were noted to be high income generating crops.

As highlighted before, crop farming is not a common activity in Turkana North sub-county and has barriers to entry due to the required infrastructure. Most of the farmers highlighted that they were pure pastoralists before they embarked on crop production with the support received from FID. The project took up, communally nominated members of different communities, into their agricultural vocational program for capacity building.

The successful candidates were selected based on their community recommendation, vulnerability, interest and/or potential for crop production. Most farmers cited the effects of drought and conflicts and the following loss of their animals as the main reason for them to consider agriculture as an alternative livelihood strategy. However, they do not consider agriculture as an alternative to pastoralism, but as a complementary activity.

The following words were recorded during the interviews of farmers.

Michael, 40 years old, said, "...*I wondered what I would do since the drought had killed my animals*...".

A woman, 52 years old, said: "… *we had animals as well, but we got attacked by raiders who took away the animals and killed my husband*…".

The vocational program is mainly constituted of men, as compared to women, since they are tied to their cultural responsibility of taking care of their homes and nurturing children. Youths did not seem to have fully embraced farming and were inclined to other livelihood activities.

All the respondents emphasized the importance of FID in building pastoralists' capacities in farming, through practical and concrete activities. It consists of three phases: training, transfer of technology and farm visits.

Training	Transfer of Technology	Follow up Farm Visits
- 5 months Agricultural Training - Adult literacy Program -Full Board Accommodation	- Gravity powered drip systems with a 200/1000L tank - 600 m Dripline -Seeds, pesticide -Farm tools	- Agronomic support - Repairs on the drip line. -Seeds, pesticide - Monitoring progress

Structure of the program

The key informant interviews with the FID staff underscored the training and capacity building approach.

The training is carried out in an agricultural vocational school where the selected pastoralists are hosted for 5 months, learning basic theoretical and practical agricultural knowledge in irrigated crop production. The

program has a strong emphasis on practical, transferrable skills, including agronomic practices, maintenance of the drip irrigation practices, marketing and nutrition too.

Informants insisted on the duration of the program as a key determinant in the adoption of irrigated crop production by pastoralists since it allowed adequate time to build the necessary skills and ensure their sustained engagement in farming after the program. After the training, farmers are assigned a plot of land, equipped with a family drip kit system, seeds, pesticides and tools to kick start their farming.

Leo, a key informant from FID, said: *"…many people are saying, why don't you train the farmers in their place?... I think it's good to take them away from everything, so that you're not focused on your family, your animals, you're just focus on what you're learning…that's why it's made of five months, so that they can see all the process of how the plant is growing, the preparation of the land, what we have to do to take care of the plant, the harvest so that is the big idea behind it… so that way the five months is not only because of the knowledge but also to pass the experience of being a farmer…."*.

Steve, from FID, said: *"When they are receiving the training, they eat what they are producing. These people, they are not used to vegetables, fruits like melon, watermelons. So, during the training they eat whatever we produce, and they get to understand the benefit of vegetables in their body."*

John, a government extension officer, said: *"… the way they have structured their training process; I think it works better. It now initiates these pastoralists to real farming. Just because of the period of time. Because there's the theoretical time for class, attending classes and there are practical classes. Then in a period of six months, this is already a transformed farmer. A farmer who is ready to absorb this technology…"*.

In addition to the extensive training, the pastoralists receive field visits periodically from the FID staff to evaluate and advice farmers on agronomic practices, and deliver inputs such as seeds and fertilizers, or repair faulty components in the irrigation systems. Active farmers act as catalysts for irrigation development since they help in mobilizing other pastoralists into crop farming. Discussions with key actors revealed loopholes in the capacity building methods employed in local irrigation interventions, which rely on short trainings, demo farm visits which are not sufficient to activate and sustain pastoralists in farming.

In terms of farmers' achievements, most farmers said that, despite the size of plots, they had improved diets and easier access to food. Additionally, they saved money and time, since they were not obliged to walk in the wild gathering wild fruits or even purchase food from the distant market of Lodwar. The key informants highlighted improved diets and access to food as one of the success criteria of the intervention due to the criticality of food insecurity in this pastoral community.

The pastoralists - farmers mainly sell their products at the local level, due to the difficulties of accessing distant markets, especially to transport infrastructural gaps. Their market base includes households within their communities and nutritional centres or schools under Faith Baed Organizations. Occasionally, some farmers hitch a ride in the Catholic missionary vehicles to sell their produce in distant towns which do not have access to fruits and vegetables.

> *"…most of our farmers are near a nutritional center, where these malnourished children are being fed, and they sell their produce as part of the children's diet plan …*"

Muya, 28, a male key respondent from Lake zone ward confirmed that he supplies the school with produce,

> *"… sometimes they come and buy some produce from this farm of mine to supplement the children's foods, maybe the maize and the beans…"*.

Some farmers weighed in on the importance of the farming ventures since they had managed to invest through the incomes they had generated from farming. For instance, some bought livestock to replace their

lost herds, and for their resale value, as this remains to be a significant economic activity among pastoral communities. Other farmers had opted to branch into upcoming, alternative livelihood activities, including motorcycle delivery and retail businesses.

Edukan (male, 25) from Lake zone,

> *"… I was able to buy 3 camels. I would sell spinach and save, that applies to cowpeas and watermelons, I would buy goats one by one. They are now 40..."*

Ebei, 30, a male respondent from Lake Zone explained how he spent his earnings from the drip-irrigated farm,

> *"… I invested the money in a retail food business, paid kids school fees, buying goats, buying food…"*

Elim, 51, a male respondent from Lapur ward shared that his earnings from his drip-irrigated farm helped him buy a motorcycle in cash and have a surplus to re-invest in other businesses,

> *"I have a farm, livestock, and a motorbike for business, I started a fishing business last month for my son, who cleared Form 4 while the other who cleared class 8, I put them in business."*

However, transforming pastoralists into farmers is not a linear activity. FID staff informed that several educated farmers have abandoned their garden plots, mostly for personal reasons, such as illness, marriage, relocation, transition to other livelihoods. Some also quitted due to partial commitments from their sponsors to facilitate their infrastructural needs.

Farmers and FID staff noted the criticality of water scarcity and quality in the project. In some clusters, water levels in boreholes dwindles especially during the dry seasons which severely affects farming. In such events, the community prioritizes household and livestock needs, over irrigating the plots, causing the loss of crops. The key informants, who play key roles in implementation of the interventions, therefore resorted to setting up farming clusters around boreholes with stable water levels and primarily dedicated to agriculture.

Leo from FID said: "… *so once a community has water for doing agriculture, it must be really enough because, if it's just minimum water people will give priority for the consumption of their families and of the animals*."

Similarly, poor water quality in some schemes has caused the salinization of soils and occlusion of drip lines.

Steve, from FID said: "… *the soil became too saline, that could not support agriculture anymore, to a point that farmers in that clusters had to leave… We are working on that by avoiding installing the drip irrigation*

in the places that the water is not suitable, or it has a high level of calcium carbonate, magnesium carbonate, all the salts that lead to drip blockage".

A woman from the most affected cluster, Kaikor Community Farm said: "*Our water here has poor quality, and the salts would block the drip lines and therefore we had to switch to furrow irrigation. We used the driplines for 1 year*".

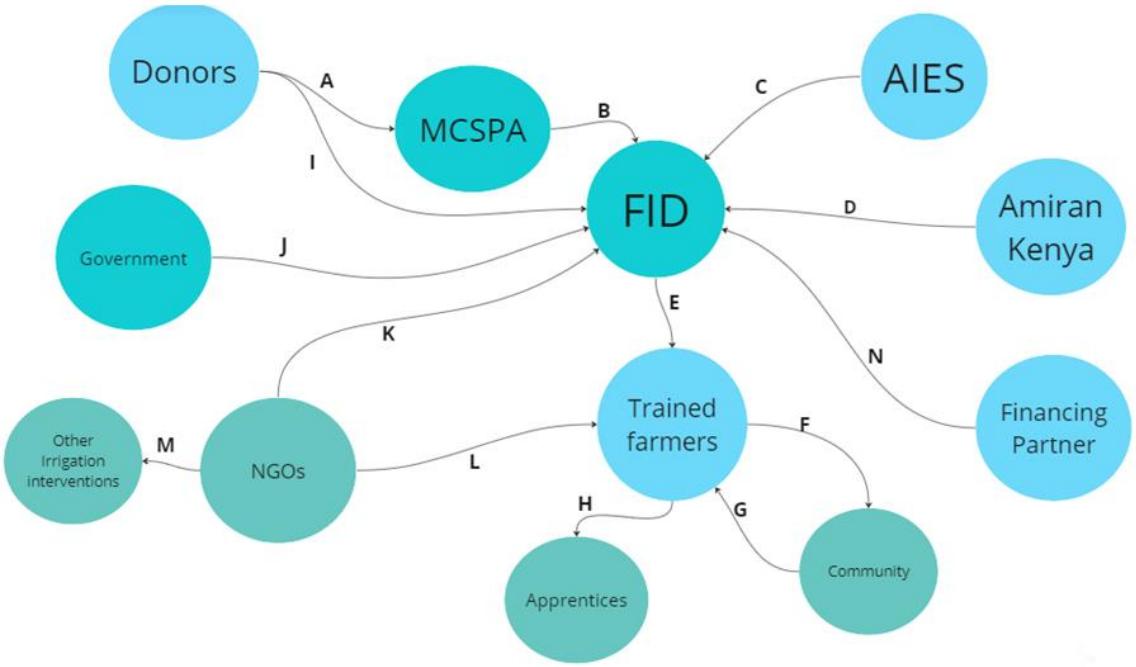
Farmers also highlighted the challenge of regular access (physical and financial) to technical inputs such as seeds, pesticides and some tools.

Michael 40, a male respondent from Lapur ward highlighted the need for input supply in the region and said:

"*We get seeds from Lobur (FID) at around Ksh 20 (subsidized price), while we get pesticides freely… it has probably taken five months from them to come, that means I get challenged in terms of pesticide supply, therefore crops suffer damages and also we suffer the challenge of supply of seeds…*".

Lorima, 35 a female respondent from Lapur ward was asked if she would continue farming without FID's intervention, said: "*I don't think we will survive. This is because, they follow up on us, provide us with seeds, pesticides… I would not do it on my own, unless I team up with two or three of my friends. I still need FID to bring the seeds, because I need them, and they need the money! Where else would I buy these items?*".

Discussions with the respondents highlighted the key actors who consist of the ecosystem behind irrigated agriculture in Turkana North sub county. The resulting data was synthesized into the following diagram. FID was identified as the most important actor, in organizing and coordinating pastoralists strategic actors from the government, research and donors towards supporting pastoralists in adoption of drip irrigated agriculture. Pastoralist farmers were also considered as important actors who are creating local networks and are contributing to farming popularization among their kinsmen.



Key Actors in the Support Ecosystem of Irrigated Agriculture in Turkana North Sub County

It was concluded that in the investigated area:

- Irrigated agriculture is an activity that may support livelihoods of vulnerable pastoralists, offering them the opportunity to have better diets and alternative or diversified incomes, useful to reinvest in important livelihood assets.
- Agricultural products can be commercialised at the local level, with customers being community members and institutions such as schools, health and nutritional centres, in need of locally produced, plant-based foods.
- Farming needs investment in irrigation systems, including boreholes with good quality of water to avoid soil salinization or occlusions of drip irrigation pipes, boreholes solely designated to farming to avoid competition over resources, especially during droughts, with domestic and animal needs.
- Irrigated agriculture needs a structured, comprehensive approach to agricultural education of pastoralists, to facilitate effective transfer of skills and experience to the pastoralists.
- It needs fully functional bodies with clearly defined mandates in providing key support services, including the maintenance of irrigation infrastructure and technologies, such as boreholes and pumps, access to technical inputs and markets.
- Extension services are a critical component in ensuring sustainability of the irrigated farming interventions, especially in such fragile environments. Particularly, they are essential in providing training, agronomic support and assisting in access to inputs, a key condition for keeping pastoralists into farming activities.

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Assessing the entrepreneurial resilience in the agri-food sector in Mount-Lebanon: exploring challenges and coping strategies

Author: Maroun BOU MATAR (Lebanon)

Supervisors: C. Salameh (Holy Spirit University of Kaslik, Lebanon),
H. El Bilali (CIHEAM Bari, Italy)

What were the research background and objective?

In Lebanon, agri-food enterprises make up 26% of industrial establishments that contribute to 2.9% of the country's GDP. However, the ecosystem of Lebanese agri-food entrepreneurs has not been fully explored. Challenges and crises are emerging quickly, and entrepreneurs are striving to overcome those difficult circumstances. It all started in 2019, when Lebanon faced many political, economic, social, financial and health crises in addition to the Beirut port blast affecting businesses in all sectors. This has led to limited resources, market volatility, changing consumer preferences, political instability, lack of infrastructure, and brain migration. This situation can hinder their growth and sustainability, which can influence rural development, food safety and the overall economic situation. In response to these uncertainties, entrepreneurial resilience has gained traction on three levels: economic, social, and environmental.

Within this framework, this study aimed at investigating how agri-food enterprises can adapt, withstand shocks, and seize opportunities to ensure viability; understand the challenges faced by entrepreneurs and the strategies used to build resilience and identify the contribution of resourcefulness, innovation, and adaptation to SME's resilience. The research focused on Mount-Lebanon territory, where 48% of agri-food businesses are situated.

How was the research implemented?

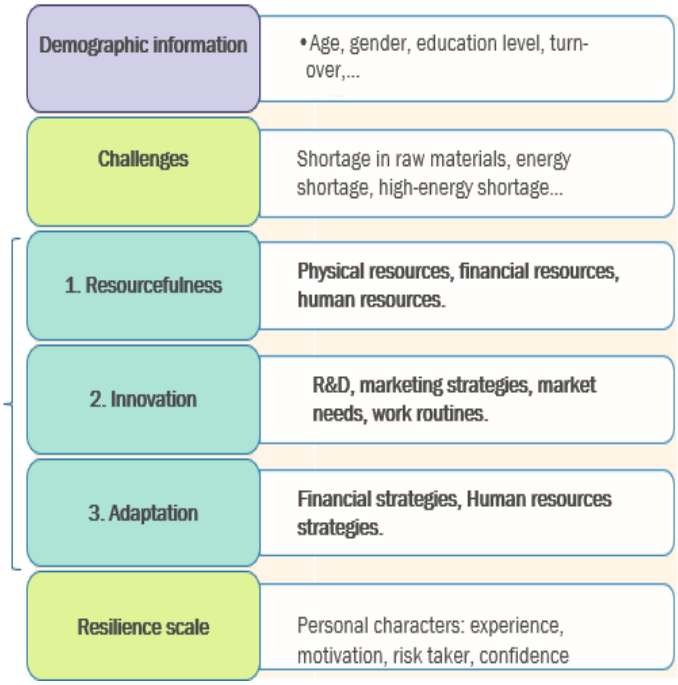
The study area consisted of 6 districts in Mount-Lebanon governorate: Jbail/Jbeil; Kesrouan/Keserwan; EL Metn/Matn; Baabda, Aley and Chouf districts.

A combination of qualitative and quantitative research methods was used to meet the study's requirements: while quantitative research relied on carefully designed surveys to collect quantifiable data from agri-food entrepreneurs in the Mount Lebanon area, qualitative research involved conducting interviews with pertinent stakeholders.

A comprehensive list of agri-food SMEs in Mount Lebanon was compiled using various sources, such as contacts with business incubators, online research, internships at Fair Trade Lebanon NGO, participation in entrepreneurial development events, and engagement in local markets. Based on the specific criteria, thirty-two SMEs were selected from the initial list and contacted.

Map of Lebanon

On-site visits to these 32 SMEs were performed on specific dates to meet with the owners and managers. The survey's questionnaire consisted of four parts concerning the demographic information, challenges faced, resilience variables (resourcefulness, innovation and adaptation) and resilience scale. Each resilience variable encompassed different subcategories such as physical resources, human resources, financial strategies and others.



The four parts of the questionnaire

By establishing a close connection with the owners and managers, this approach helped to better understand their viewpoints and issues. Additionally, these visits gave a deeper comprehension of the business environment, which improved data collection.

Additionally, being physically present provided insightful information about the nuances of the agri-food business that remote data collection systems would have missed.

SPSS (Statistical Package for the Social Sciences) version 29.0 was used to systematically organise and analyse the survey responses after the data was collected. Following the assignment of a numerical value and scale to each response, the software processed the data. Several statistical methods, such as correlation analysis and descriptive statistics, were used to make linkages between the elements of interest and resilience.

The interpretation of the p-value was crucial in determining the significance of the tested hypothesis; if the p-value was less than 0.05, which denotes a 5% risk threshold, the null hypothesis would be rejected, suggesting a significant difference. The Cronbach alpha test was used to provide ratings based on an assessment of the questionnaire items' reliability.

The Chi-square test was also used to assess the relationship between the sociodemographic characteristics and each of the difficulties that SMEs confront. Because the approximation method was insufficient, Fisher's exact test was employed to determine the results when more than 20% of cells had expected frequencies less than 5.

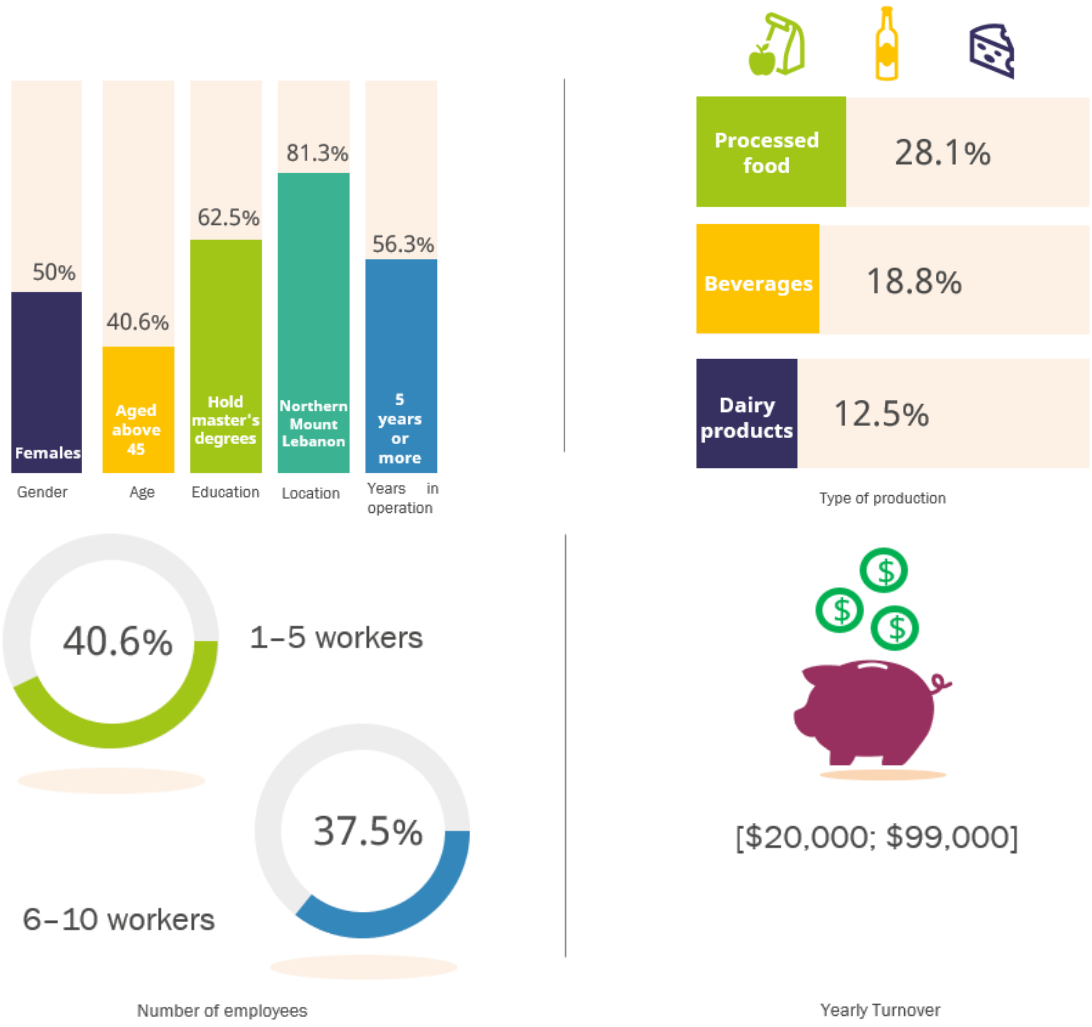
What were the main findings?

The demographic profile of the participants showed a gender distribution of 50% female and 50% male. With 40.6% of the respondents being over 45 years old, a sizeable chunk of the entrepreneurs is older than 35. This group is indicative of the knowledge and education inside the sector, which fosters the generation of fresh concepts and deliberate decision-making. Dairy products, drinks, and processed foods make up the bulk

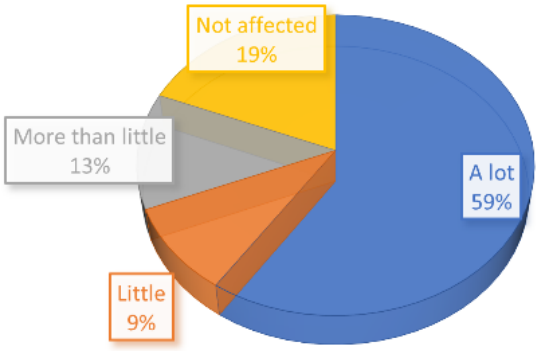
of SMEs' areas of expertise. About 81% of SMEs are in the northern Mount Lebanon region, with 40.6% of businesses employing one to five people and 37.5% employing ten or more.

SMEs have been in business for five years or longer, which shows stability and industry knowledge. The bulk of small and medium-sized enterprises (SMEs) in the agriculture and food industries earn between $20,000 and $99,000 annually, while having a range of income levels. This shows the financial diversity, market reach, and various degrees of success that these companies have.

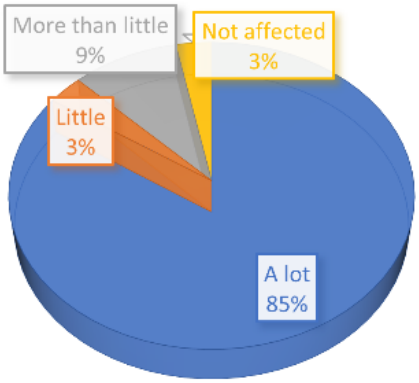
Socio-demographic characteristics of the participants



Moving to the challenges, energy shortages, along with the prohibitively high cost of energy sources, provide a serious challenge to Lebanon's agri-food SMEs. Most SMEs (59%) stated that energy scarcity has a considerable influence on their business operations, and an overwhelming 85% stated that their company has been greatly impacted by the high cost of energy. Power outages and the lack of refrigeration for food are major issues for Lebanon's agri-food industry. These factors increase the likelihood of food spoilage and reduce the quality and shelf-life of food products. The incapacity of small enterprises and startups to traverse and overcome these obstacles is seriously threatened by the collapse of infrastructure.

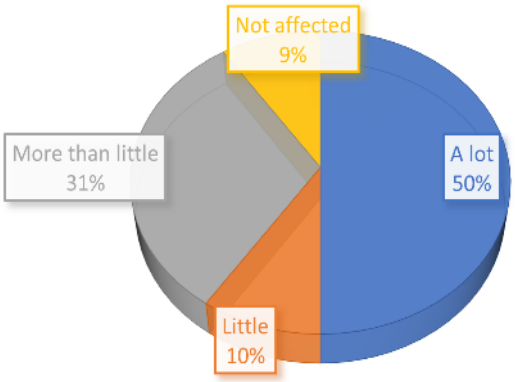


Impact of energy shortage

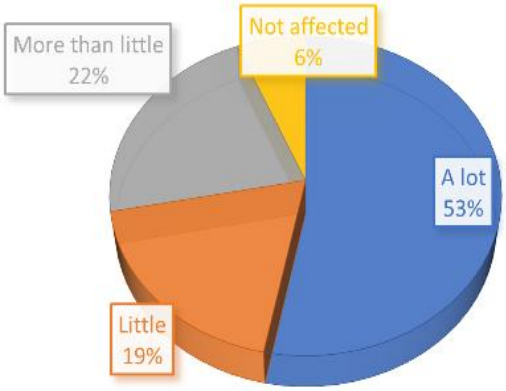


Impact of high energy cost

On the other hand, SMEs faced major challenges due to a lack of funding and a decline in the purchasing power of consumers. Financial limitations saw a startling 81% of the SMEs polled saying they had a substantial or significant influence on their company. Given that 53% of SMEs said that the decline in consumer purchasing power had a significant effect on their operations, it is evident that SMEs depend on consumer purchasing power.



Impact of the lack of financial resources on SMEs



Impact of the purchasing power on SMEs

Among the socio-demographic factors, it was shown that higher education levels impacted consumer purchasing power, explaining that entrepreneurs with high education tend to have products targeting those customers with a high purchasing power, justifying the fact that elevated education levels among business owners typically correlate with an increase in consumer buying power, as customers are willing to pay a premium for innovative or high-quality products. Additionally, various types of enterprises that are energy consuming showed the sole statistically significant difference (p=0.051, rounded to 0.05) with high energy prices as the most challenging factor among these organizations. This highlights the significant influence of energy costs on the operational dynamics and profitability of enterprises in the researched industries. This challenge appears to be common across different types of organizations and should be addressed through efficient resource management, the development of efficiency strategies, and the exploration of alternate energy sources or cost-cutting measures to mitigate its negative consequences.

Correlation between education level and challenges

Variable 3: Owner's / Manager's Education level						
Modalities	High school diploma or less	Bachelor's degree	Master's degree	Doctorate or equivalent	**Pearson Chi-Square Tests p-value**	**Difference Statistical Significance**
Challenges	Significantly affected (%)	Significantly affected (%)	Significantly affected (%)	Significantly affected (%)		
Brain migration and loss of employees	0.0	33.3	25.0	0.0	0.521	*ns*
Shortage in / High prices of raw materials, specifically imported ones	0.0	0.0	35.0	0.0	0.146	*ns*
Energy shortage	50.0	83.3	70.0	100.0	0.541	*ns*
High-energy cost	75.0	100.0	95.0	100.0	0.394	*ns*
Lack of financial resources	75.0	100.0	75.0	100.0	0.482	*ns*
Decrease of the consumer's purchasing power	25.0	100.0	75.0	100.0	0.046	*

*ns: not significant, * : significant, * * : highly significant*

Correlation between type of enterprise and challenges

Variable 4: Type of Enterprise												
Modalities	Beverages	Dairy Products	Preserved and Processed Foods	Honey and Bee Products	Confectionery and Sweets	Medicinal and Aromatic Products	Organic Waste Management and Consultancy	Meat and Deli Products	Baby Food Production	Mix (more than one category)	**Pearson Chi-Square Tests p-value**	**Difference Statistical Significance**
Challenges	Significantly affected	Significantly affected	Significantly affected	Significantly affected	Significantly affected	Significantly affected	Significantly affected	Significantly affected	Significantly affected	Insignificantly affected		
Brain migration and loss of employees	50.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.623	*ns*
Shortage in / High prices of raw materials, specifically imported ones	16.7	25.0	44.4	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.803	*ns*
Energy shortage	83.3	75.0	88.9	33.3	100.0	0.0	100.0	0.0	0.0	75.0	0.174	*ns*
High-energy cost	100.0	100.0	88.9	100.0	100.0	100.0	100.0	0.0	100.0	100.0	0.051	*
Lack of financial resources	100.0	100.0	66.7	66.7	100.0	100.0	100.0	0.0	0.0	100.0	0.108	*ns*
Decrease of the consumer's purchasing power	100.0	75.0	66.7	33.3	50.0	0.0	100.0	100.0	100.0	100.0	0.268	*ns*

*ns: not significant, * : significant, * * : highly significant*

In addition, T-Tests were conducted to examine the relationships between socio-demographic factors and resilience, and no significant relationships were found.

Regression analysis (ANOVA test) of resilience variables with resilience score

Variable	ANOVA test		Correlation relation type
	F	p	
Adaptability	16.559	0.000	The relation between the two variables is highly correlated. **
Resourcefulness	5.976	0.021	The relation between the two variables is less correlated. *
Innovation	0.698	0.410	The relation between the two variables is not correlated. *ns*

*ns: not significant, *: significant, * *: highly significant*

A regression analysis was undertaken to determine the influence of resourcefulness, innovation, and adaptability on the resilience score. Results showed that the relations adaptability-resilience ($F = 16.559$, $p = 0.000 < 0.05$) and resourcefulness-resilience ($F = 5.976$, $p = 0.021 < 0.05$) are correlated which reveals a positive trend, indicating that SMEs with higher adaptation ratings and diversified resources availability also demonstrate higher levels of resilience. However, it is not the case for innovation-resilience.

The study identified key traits essential for the success of SMEs, including adaptability and resourcefulness. Entrepreneurs exhibit a strong commitment, flexibility, and confidence when facing challenges. Adopting a comprehensive approach that emphasizes these qualities may enhance resilience, particularly within the dynamic context of Lebanon.

Proposed strategies for SMEs encompass support for emerging businesses and home-based enterprises, the provision of customized coaching and training programs, as well as the incorporation of export planning and market analysis. The study highlights the pressing issues of increasing energy costs and shortages in Lebanon, necessitating governmental reforms, investments, and policy interventions. Utilizing alternative energy sources, such as solar panels, alongside financial resources, could alleviate the effects of elevated energy expenses.

This study enriches the existing literature on SME resilience in Lebanon by offering specific evidence relevant to the local context. Future research should investigate various methodologies to deepen understanding, conduct longitudinal studies to monitor the resilience of SMEs over time, assess the efficacy of support from non-governmental organizations and business incubators, and evaluate the effectiveness of current policies and interventions aimed at strengthening SME resilience.

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Farmers' perceptions of land degradation and management measures – a case study of Chisazima and Kaunda villages in Kasungu, Malawi

Author: Fatsani Damson CHIMUTU (Malawi)

Supervisors: I. Mambo & D. Kambewa (LUANAR, Malawi),
L. Lamberti (CIHEAM Bari, Italy)

What were the research background and objective?

Malawi is a rural country whose economy relies heavily on agriculture, and land degradation (LD) is a major challenge to land productivity. This has prompted the government to make LD control a key target in its national agricultural policy. In recent years, various programs and projects have been implemented to curb land degradation, often without achieving the intended results. LD continues to hinder the production of a diverse array of crops essential for a nutritious diet. The resulting decline in productivity, dietary diversity, and prolonged periods of seasonal hunger have led to food insecurity, malnutrition, and deaths. Additionally, deforestation for agricultural expansion threatens biodiversity and ecosystem resilience. The depletion of natural resources further intensifies competition for land and water, leading to conflicts and social tensions.

Most of Malawian farmers are smallholders living in poverty. In recent years, food production levels have decreased, leaving 80% of the rural population facing a five-month gap in food supply before the next harvest. Experts emphasize that many LD programs and projects fail because they overlook farmers' perceptions and their participation in planning and management (Boschetto et al., 2010). This oversight has resulted in projects falling short of addressing local needs, thereby limiting the effectiveness of solutions to land degradation.

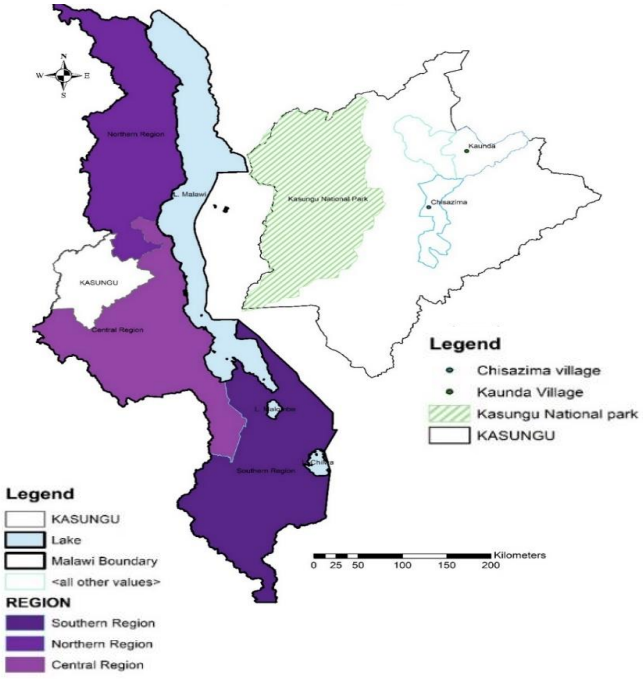
This study aimed to explore how poor and smallholder farmers in Malawi approach land degradation, to understand their perception of the issues, the impact on their livelihoods, and the measures they take. Additionally, it investigated how farmers perceive the support from key actors involved in land degradation management.

The study's results may help inform relevant stakeholders about the factors driving smallholders' land management actions, and identify misalignments or limitations in programs and projects, allowing for better alignment with farmers' needs and greater engagement in concrete actions.

The study was conducted in the central region of Malawi, in Kasungu district within the Mkanakhothi extension planning area. This region is remote, lacking modern infrastructure, and home to numerous projects promoting sustainable agriculture. It is also historically known to be affected by hunger and the devastating effects of natural disasters, which have been exacerbated by climate change.

How was the research implemented?

The research adopted a case study design.
The studied area falls in the Kasungu district in Mkanakhothi EPA, where the villages of Chisazima and Kaunda were identified as representative areas where land degradation is a problem for local farmers and where many projects and stakeholders influence land management in the area.
The landscapes are hilly with planes presence, with maize and tobacco the main cultivated crops by many smallholders.
Rainfall is of about 680mm per year, distributed from November to April, often interrupted by droughts and dry spells. The soils are slightly acidic ultisols with low organic matter (1.6% at 0-15cm and 1.0% at 15-30cm) and are poor, consisting coarse to moderately fine sandy clay.
The research adopted a qualitative approach to gain an in-depth understanding of land degradation and its impact on the social dynamics.



Chisazima and Kaunda villages as located in Malawi

Farmers' views were explored using various participatory methods:

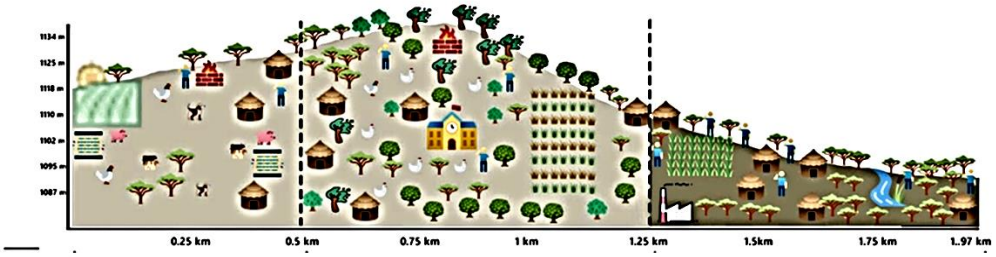
- 2 transect walks were organized together with local farmers and extension officers to discover and discuss with local farmers and extension officers the land degradation phenomena and causes.
- 40 focus group discussions (FGDs) were held with farmers to understand the effects of land degradation on their livelihoods, and deeply the causes and remedies.
- A FGD was organized for a timeline identification of the events farmers considered important in land degradation evolution in the area.
- A Venn diagram exercise was organized with a group of farmers to identify the major stakeholder farmers consider important in land degradation management.

The research was conducted during the dry period in November. The identification of respondents was purposive, involving knowledgeable farmers selected with the help of government extension officers. We ensured diverse perspectives by considering participants of different: age, experience, gender, and location.

Thematic analysis was used to systematically analyse the data, complemented by secondary data. The analysis utilized Atlas.ti software for organizing extensive datasets, following a detailed process from data familiarization to conceptualization and presentation.

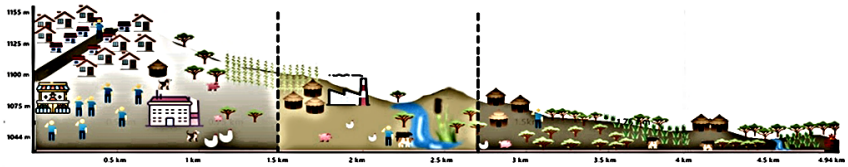
What have been the main findings?

The two transect walks implemented with farmers and extension officers allowed to recognize the importance of LD for local farmers. They clearly considered it as a main problem in the area and identified causes in relation to the specificities of landscapes and human actions. In Chisazima village, sandy and loamy soils, together with slope steepness were identified as key factors that induce floods and soil erosion. Regarding human actions they pointed out to the following factors: deforestation to get new farmland, continuous clean tillage of fields, overgrazing by livestock, new farming close to riverbanks, bush fires. Also, non-agricultural activities were identified as major causes of LD, specifically charcoal and bricks production, that require wood in high quantities.



	Zone A	Zone B	Zone C
Topography	Lower area	Flat areas located on a hilly terrain of the landscape	Steep slope located in low lying areas of the landscape
Soil type	Sandy soil	Course sandy soil	Loamy soil
Farming systems	Integrated crop and livestock systems.	Tobacco farms	Tobacco estates, vegetable irrigation farming.
Causes of LD	Severe deforestation, deep and clean tillage	Brick burning, overgrazing	Bush fires, floods, establishment of new farms.
Indicators of LD	Exotic trees i.e., eucalyptus globulus, and Cassia abbreviata, less tree diversity	Soil fertility depletion indicator plants (Matondo), ravines	Soil deposits, Gullies, less vegetative diversity
Sustainable land management measures	Animal manure application, contour ridges and waterways.	Afforestation and mixed cropping	Mixed cropping of leguminous crops, and residual incorporation

Key landscape features observed in Chisazima village



	Zone A	Zone B	Zone C
Topography	Hilly areas of the landscape	Low areas of the landscape	Lowest lying areas of the landscape
Soil type	Dominated by erodible course sand	Mixture of fine sand and loamy soil	Dominated by loamy soil
Farming systems	Maize dominated	Integrated crop and livestock system, maize and tobacco	Integrated crop and livestock system, maize and tobacco
Causes of LD	Deforestation and clean tillage	Overgrazing, brick making, clean tillage and farming near river banks	Weak and ridges along the slope, charcoal burning and farming near river banks
Indicators of LD	Whitish soils, less tree diversity, frequent rills, broken ridges.	Frequent gullies,	Sand deposits in rivers
Sustainable land management measures	Agroforestry, waterways and vertiver grass	Afforestation, bee keeping, ridges, manure pits and rock riprap	Afforestation, animal manure and waterways

Key landscape features observed in Kaunda village

While discussing the impacts of LD on livelihoods, farmers agreed that these are evident. They said that over the years, there has been a consistent and continuous loss of soil fertility. They indicated that their key crop harvests have reduced significantly over time, and they experience longer periods of hunger compared to previous times. For instance, they recalled that maize harvests, the main staple crop, were higher in the 1970s, when 'we cultivated crops successfully without using chemical fertilizers, achieving bumper yields.' At that time, the maize produced in the previous season would last and meet the current season's harvest. However, that is no longer the case. Records taken from farmers during FGDs show that they recall maize harvests being 2-3 times greater than what they currently achieve. They also affirmed that in the last decade, the increased use of chemical fertilizers is no longer leading to higher yields as in previous years, and this coincides with a consistent increase in fertilizer prices.

Data on changes in maize were collected from FG participants

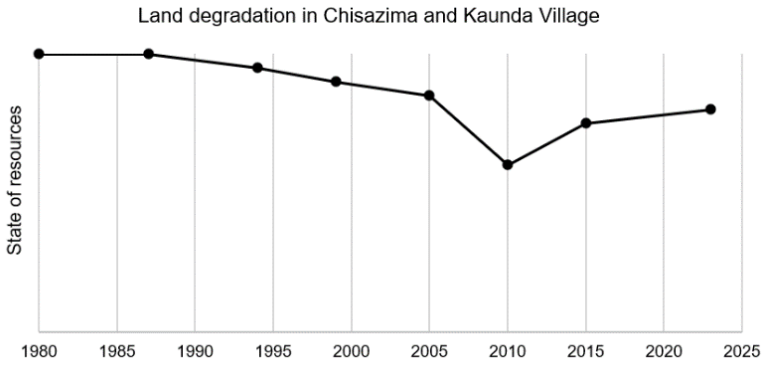
Names of FGDs	Before 1980s	After 1980s
Mchacha (f)	N/A	500 - 750kg
Maseko (m)	2700kg	1250kg
Maseko (f)	5 Ox-carts	1 Ox-cart
Mkhwapu (f)	6 Ox-carts	3 Ox-cart
Kaunda (f)	N/A	500kg
Duti (m)	N/A	N/A
Duti (f)	3000kg	750kg
Chisazima (f)	1000-1500kg	250-750kg
Chisazima (m)	N/A	900kg

Population growth and poverty were considered key factors that are determining a misuse of land. The need to pursue livelihoods, push farmers to intensify cultivations or extend it to challenging areas. Many farmers' quotes were like the following:

"*Imagine a situation where your home lacks food, but your field is filled with trees. Under desperation conditions to find food, you find yourself compelled to resort to cutting down those trees in order to generate the funds needed to purchase food*."

Similarly, they said that "*continuous cultivation and farming in fragile areas, such as mountainous lands, riverbanks and wetlands is increasing*". Farmers in both villages expressed significant establishment of new farmlands in forested areas, a scenario that demands massive removal of trees.

While discussing with farmers about the evolution of LD in their fields, they highlighted that it is a trend that started in the late 1980s and became very evident between 2005 and 2010. In the 1990s, maize and tobacco cultivation became the dominant crops, with poor diversification. In particular, tobacco production was recognized as having a significant impact due to the establishment of many large tobacco estates, facilitated by deforestation policies implemented by the local government in the 1990s, coinciding with the advent of democracy. They also noted that between 1999 and 2005, population growth, hunger, and the emergence of the charcoal industry were important factors in the intensive use and misuse of land. Problems were amplified by the severe drought in 2007, along with rainfall that has since become inconsistent, unpredictable, short in duration, but also intense, causing severe soil erosion. Surprisingly, LD was also linked to the reform of fertilizer subsidies for smallholders, which significantly reduced smallholders' access to these inputs (the quantity of fertilizer received was decreased from four bags to two as a result of this reform).



Year	Main Events:
1980 – 1987	Before the spread of tobacco farming
1987 – 1994	Stringent government policies on deforestation, few large tobacco estates
1994 – 1999	Unrestricted tobacco farming, democracy, few actors
1999 – 2005	Population increase, hunger of 2002
2005 – 2010	Charcoal production, drought of 2007, chemical fertilizer procurement reforms
2010 – 2015	Multiple actors in the fight against land degradation
2015 – 2023	Frequent hunger and erratic rains

Evolution of land degradation over time

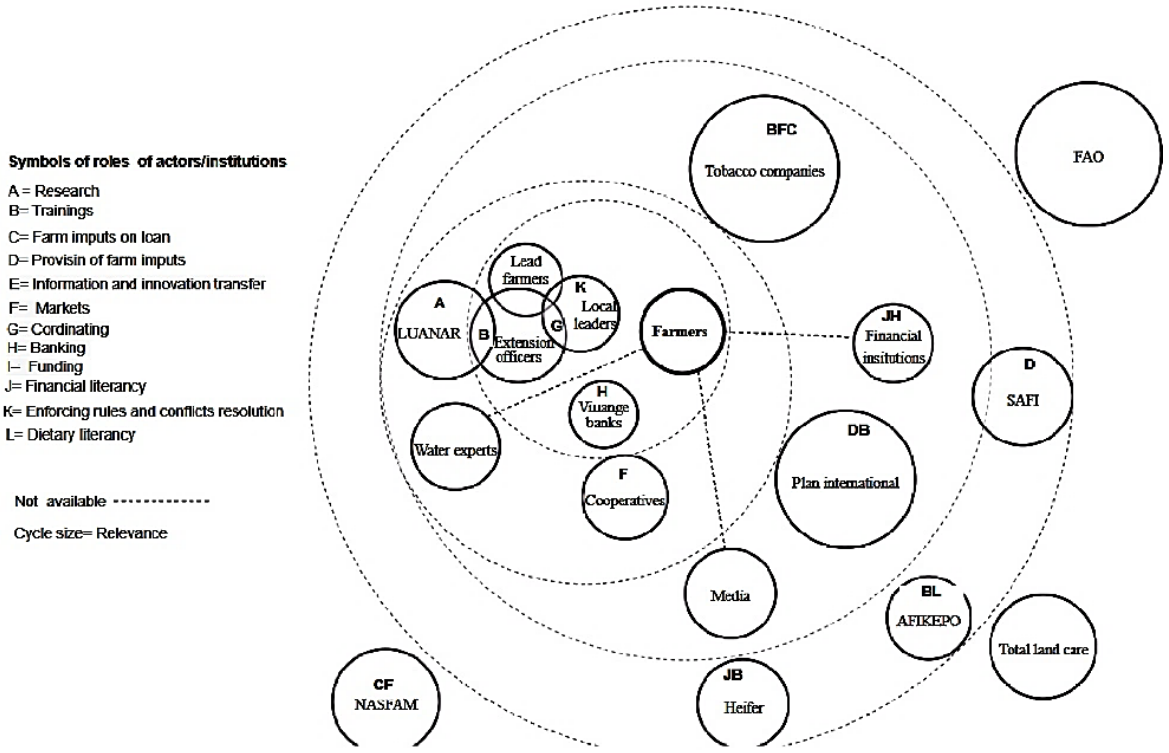
Farmers also noted that LD has been the focus of numerous actions over the past 15 years, led by various stakeholders such as international organizations, research centres, non-governmental organizations, and local institutions. These entities have implemented programs and projects aimed at empowering communities in sustainable land management (SLM) in various ways.

Farmers demonstrated a good understanding of on-farm measures that can be used for land degradation control, many of which are recommended by multiple stakeholders. However, they pointed out that the adoption of these measures is often not straightforward and is frequently hindered by the lack of inputs, small land sizes, insufficient skills, or the need for intensive labour, investment, and water access. They emphasized that, in many cases, the adoption of such measures requires collective action and cannot be effective if applied only on individual farms. As one farmer explained: "*You may have safeguarded your land with measures like box ridges, water diversions, and tree planting, while your neighbour has not. Water from higher areas washes away your soils and plants*."

Reported measures listed by farmers with the corresponding challenges

SLM Category	Mitigation measures	Challenges
Vegetative/biological measures	Tree planting/agroforestry Planting vetiver vegetative cover	Inadequate land to plant trees Lack of sapling Lack of cooperation Lack of skills
Structural/physical measures	Applying soils from anthills Box ridges Contour ridges Waterways Rock riprap	Waterlogging Labour intensive Lack of technical skills Lack of cooperation
Agronomic measures	Intercropping Mixed cropping Zero/minimum tillage Crop rotation Residual incorporation Manure application	Lack of transportation to lift manure to the field Pest and disease Lack of technical skills Scarcity of water Lack of seeds Lack of knowledge in the use, transportation to fields
Management measures	Fallowing Sustainable crop intensification Early planting	Population growth Lack of seeds Inconsistent and unpredictable rain

The Venn diagram exercise helped identify the stakeholders that farmers consider important in their territory. Many were identified, but the most significant were tobacco companies and organizations (both international and non-governmental) that provide inputs, loans, markets, and training to farming communities. While their role was not directly aligned with LD control, they were still essential in supporting farmers' livelihoods. On the other hand, other projects and organizations, such as LUANAR University and local extension services, were recognized for their efforts to engage communities in SLM. However, they faced challenges in reaching and mobilizing large farming communities and in supporting collective actions.



Venn Diagram of Key stakeholders Supporting Farmers in Land Degradation Mitigation

Farmers also underscored the importance of other stakeholders, whose action may contribute to a SLM. For instance, they recognize the importance of local financial services that are preparing farmers in farm budgeting and profit and loss calculations; or that facilitate the access to agricultural inputs through credits and loans. They also appreciated the actions of research institutions promoting farmers' network for researching and developing sustainable agricultural technologies, or of actors promoting the diffusion of stove devices less dependent on the use of wood.

In conclusion, this study showed that, in the investigated territory:

- Farmers are very much aware of LD phenomenon, and are suffering for its effects on their livelihoods, mainly in terms of reduction of harvests and incomes from agriculture.
- They clearly identify its main drivers in deforestation, intensification in tobacco and maize farming, developing of the charcoal production business. They also perceive that climate change, with more frequent severe droughts and erratic by intense rains, is aggravating the phenomenon.
- Farmers know practices and measures that might be adopted for controlling LD but they say population and poverty growth disincentive their use.
- They recognize the role of many stakeholders, with a direct or indirect influence on LDM, and highlight the inefficiencies of their actions in promoting farmers actions and adoption of measures.
- Programs and projects should work closer with farmers, through active discussions and participatory approaches, to align activities and actions to the specific socio-economic contexts.

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Socio-economic dynamics of carob farming in High Atlas: an explorative study in Azilal province

Author: Fatima-Zahra FAHIM (Morocco)

Supervisors: R. Ait Babahmad (Moroccan Biodiversity and Livelihoods Association, Morocco), L. Lamberti (CIHEAM Bari, Italy)

What were the research background and objective?

The Atlas Mountains in Morocco serve as vital hubs of economic resources and ecosystem services. Characterized by diverse altitude ranges, these mountains have long been home to communities experienced in diversifying their livelihood strategies according to the seasons.

Traditionally reliant on local resources and agricultural sector, these communities have maintained a remarkable degree of self-sufficiency, with land management techniques largely unchanged over the centuries. In addition to traditional field crops, the inhabitants of the Atlas Mountains also rely on a range of non-field edible resources, such as Almonds, Walnuts, Carob, and Olive which contribute significantly to their livelihoods through consumption, exchange, and sale for cash. However, the looming spectre of climate change threatens to disrupt this delicate balance, making the people of the High Atlas Mountains even more vulnerable than they already are. So far, changes in precipitation patterns have been observed, resulting in the loss of fruit trees in some areas. With precipitation expected to decrease by 5% in mountainous regions and 30% in southern areas of Morocco between 2011 and 2050, water scarcity is poised to become a critical issue affecting agricultural production and livelihoods in the region.

Within this challenging context, the carob tree emerges as a crucial alternative species for local communities. This resilient member of the legume family, with its ability to thrive under water constraints, holds immense economic, ecological, and ornamental significance. Providing essential ecosystem services, including soil erosion control, carbon sequestration, and nutrient cycling, the carob tree plays a pivotal role in enhancing the resilience of Moroccan ecosystems to changing climatic conditions and water scarcity. As communities in the Atlas Mountains navigate the challenges posed by climate change, the cultivation of carob offers a promising avenue for enhancing resilience, ensuring food security, and sustaining livelihoods in the face of mounting environmental pressures.

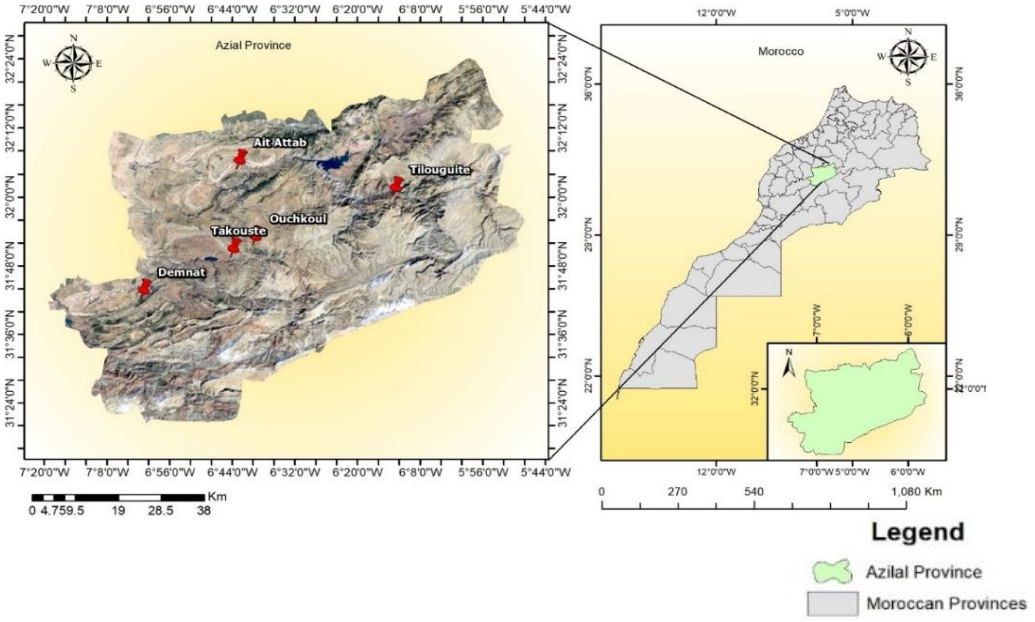
Azilal province stands out as a prominent hub for carob cultivation in Morocco, renowned for its abundant harvests, high production rates, and exceptional quality of carob pods. Recent initiatives aimed at expanding cultivation efforts and boosting productivity have further solidified the province's reputation in the carob industry. Given its pivotal role, Azilal province

serves as an optimal study area, offering insights into the complex network of carob stakeholders and highlighting the multifaceted nature of the carob value chain, emphasizing its socio-economic significance for local communities. For these reasons, the Azilal province has been considered for the present study as an area where it worth to conduct explorative research into the multifaceted aspects of carob value chain.

How was the research implemented?

This study was carried out in Azilal Province, located in the Beni-Mellal Khénifra region of Morocco. The province is situated to the north-west of the High Atlas Mountain range, and its geographical coordinates are latitude 31° 55' 0.012'' north and longitude 6° 30' 0 west with an altitude from 1,057 to 3,690 m, Jbel Azourki, above sea level. The area exhibits a mountainous landscape that forms part of the central High Atlas range, featuring various topographical elements such as steep slopes, valleys, and a few plateaux. The climate in Azilal is Mediterranean, characterized by semi-arid conditions.

The province is characterized by agroforestry property built by the rural Amazigh population, dispersed in small, isolated hamlets, in a context of rainfed food agriculture and extensive livestock farming, relatively open landscapes with pre-forest formations of trees outside the forest retained in the fields. To effectively navigate constraints such as limited time and resources, the study strategically narrowed its focus to five specific villages within the province: Ouchkoul, Takoust, Tilouguite, Demnat, and Ait Attab.



Location map of the study site in the Azilal province of Morocco, processed on ArcGIS

To explore the intricate dynamics of the carob sector in Azilal Province, a qualitative research approach was adopted. The data collection process began with a one-week field observations across the case study area, spanning from Ouchkoul to Takoust, and Demnat area and its surroundings. These field and landscape observations aimed to gain insights into the distribution and dispersion patterns of carob trees, as well as the farming practices and systems used by local communities. The Moroccan Biodiversity and Livelihoods Association (MBLA) facilitated these observations, providing local expertise and guidance.

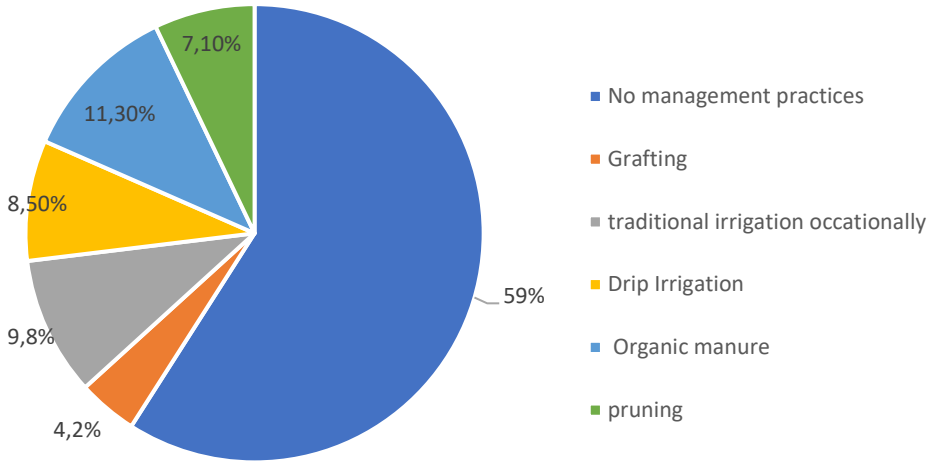
Semi-structured interviews were conducted with 39 participants, selected to represent a wide range of stakeholders including farmers, cooperative leaders, and other relevant actors. These interviews were conducted in multiple languages (Amazigh, Arabic, and French) to accommodate the linguistic preferences of participants. The interviews covered several aspects of carob farming, including cultivation practices, challenges faced by farmers, economic and social impacts of carob cultivation, and coordination among stakeholders. The interview questions were developed based on the primary objectives of the research and were organized into four sections: demographic information of interviewees, agricultural systems and practices of carob production, support actors and stakeholders, and socio-economic and environmental impacts. Additionally, a focus group was held with eight farmers from Demnat, aged 40 to 65, who shared their extensive experience in carob cultivation. The focus group session, facilitated by a semi-structured discussion guide, took place at the local farmers market in Demnat. The discussion covered common production practices, access to inputs and technical support, market utilization, socioeconomic impacts, and perceived obstacles. This collective dialogue provided valuable insights into the shared experiences and community dynamics related to carob farming.

The qualitative data collected from the interviews and focus group discussions were transcribed verbatim and translated for analysis. The data were then systematically coded using Atlas.ti software, identifying key themes such as carob farming practices, stakeholder interactions, and socio-economic and environmental implications. The results were organized into detailed tables and graphs using the EXCEL program, providing valuable insights into the typology of carob farmers in the region and their different categories. A thematic map was created to visualize the hierarchical structure of themes and subthemes, facilitating a comprehensive exploration of the data and the thematical analysis.

What were the main findings?

The study allowed to identify the main carob producers in Azilal as local farmers, who primarily engage in small-scale agriculture. These farmers have varying levels of experience in carob production, which significantly influences their agricultural practices and productivity. The demographic analysis reveals a diverse age group involved in carob farming, indicating both traditional and contemporary approaches to cultivation.

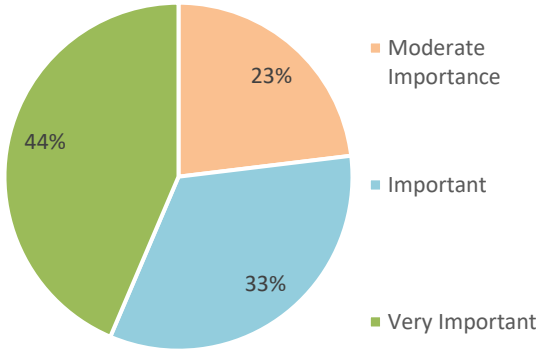
Carob plantations in Azilal are characterized by both aged and new plantations. The management practices vary, with traditional methods being predominant among older farmers, while younger farmers tend to adopt more modern techniques. The study highlights the resilience of the carob tree in arid environments and its ability to thrive with minimal water, making it an ideal crop for the region's challenging climatic conditions.



Agricultural Management Practices

In Ouchkoul and Takoust, farmers see carob cultivation mainly as a supplementary resource. Tilouguite farmers have diverse views due to varied socio-economic conditions. In Demnat, most farmers regard carob cultivation as crucial to their livelihoods, indicating a significant reliance on it for income. Ait Attab farmers also view carob cultivation very positively, recognizing its commercial potential. These findings highlight how local contexts influence the perceived importance of carob cultivation, with some areas viewing it as essential for income and others as a supplementary resource.

Farmers' perceptions of carob cultivation are categorized into economic, social, and environmental aspects. Economically, carob farming is seen as a vital source of income, contributing significantly to household finances. Socially, it fosters community cohesion and cultural heritage, as traditional practices are passed down through generations.



Carob Cultivation Importance

Environmentally, carob trees play a crucial role in soil conservation and ecosystem stability, highlighting their importance in sustainable agriculture. Carob trees contribute to soil conservation and prevent erosion, which is critical in the mountainous terrain of the High Atlas. Their resilience to drought and minimal water requirements makes them a sustainable crop choice amid climate change concerns.

The study emphasizes the role of various organizations and support structures in promoting carob farming. The establishment of cooperatives has facilitated better market access and fairer pricing, although challenges remain in reaching broader markets, cooperative structures enhance social cohesion and collective bargaining power among farmers. In addition, farmers' associations provide essential services, including technical assistant and advocate for farmers' interests, influencing policy decisions and securing support from governmental and non-governmental organizations. Government agencies like the Provincial Directorate of Agriculture and the National Agency for Water and Forests play a pivotal role in policy implementation and resource allocation. Provincial and national agencies offer technical assistance, research support, and infrastructure development, promoting sustainable agricultural practices.

"Even with the price fluctuation of carob, it remains an important crop for farmers in this region since we don't provide anything, it requires less work, and it has a large income".

(Lahcen Dabich, 43-year-old).

"Carob cultivation boosts local employment, especially on farms with over six trees, increasing labor demand during harvest season. This enhances income generation and fosters community cooperation.

(Hassan Ben Hami, 33 years old).

"For me, when comparing olive trees to carob, I can list numerous benefits of carob over olive. As a beekeeper, I've observed that carob serves as a refuge for these pollinators, contributing to the production of high-quality honey. Moreover, considering the mountainous terrain in our area, the well-developed roots of the carob tree play a crucial role in penetrating rocky soil, stabilizing it, and extracting water from deeper horizons."

(Hassan, 45 years old).

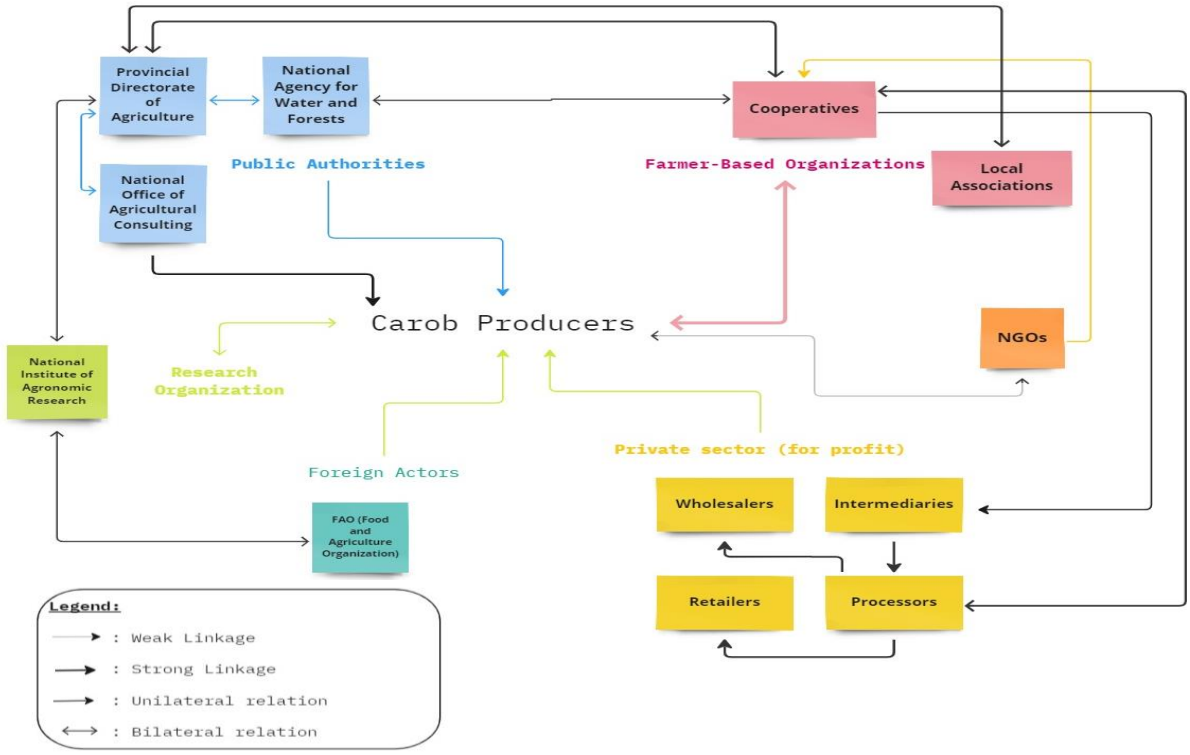
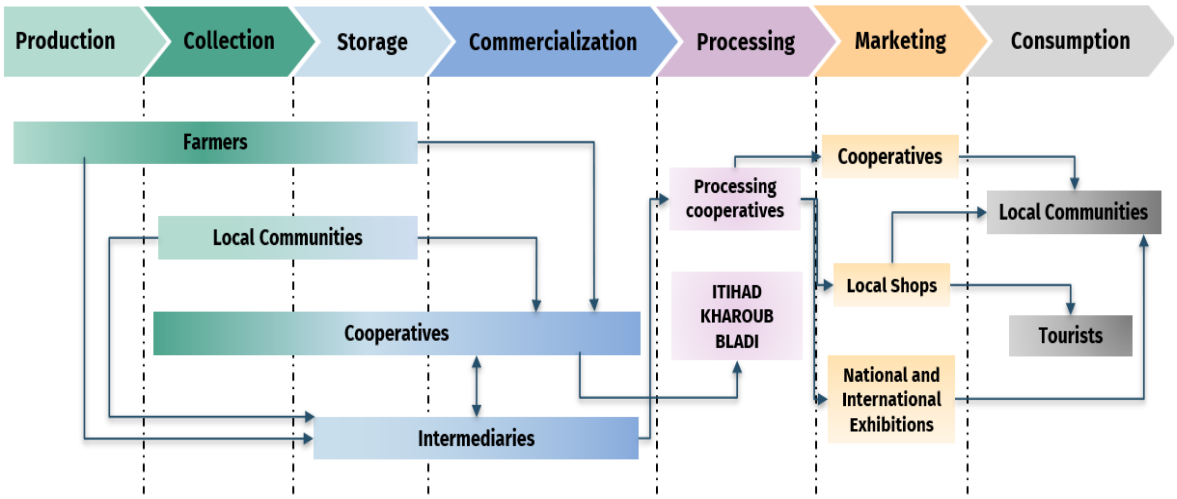


Diagram representing the interactions among Stakeholders

The carob value chain in Azilal Province shows that smallholder farmers play a crucial role in cultivation, harvesting from communal forests or their lands. During abundant harvests, stakeholders store carob to sell later at higher prices, optimizing profitability. Post-harvest, carob pods are sold to intermediaries or cooperatives and may be used as livestock feed. Processing, managed by local cooperatives like "ITIHAD KHAROUB BLADI" and "HibatAtlas," enhances value through cleaning, sorting, and transforming carob into products like powder, syrup, and cosmetics. The processed products are distributed through local shops and exhibitions. The study highlights the need for structured marketing channels to empower farmers and ensure equitable value distribution emphasizing on its importance for sustainable agriculture and economic development, underscoring the potential for collaborative efforts to maximize the carob value chain's potential.



Carob Value Chain in Azilal Province

The research identifies several challenges facing carob farmers, including market volatility, limited access to modern agricultural technologies, and environmental pressures such as climate change. To address these challenges, the study recommends improving market access by developing better infrastructure for transportation and storage to reduce post-harvest losses. Enhancing market information systems to provide real-time data on prices and demand is also suggested. Promoting the use of modern agricultural practices and technologies to increase productivity, along with providing training and extension services to equip farmers with the necessary skills, is essential. Implementing soil and water conservation techniques to mitigate the impacts of climate change and encouraging agroforestry practices that integrate carob trees with other crops to enhance biodiversity and ecosystem services are also recommended.

It was concluded that:

- carob cultivation, in the study area, is contributing to support livelihoods of part of the local communities.
- carob practices are sustainable, requiring minimal inputs use and promoting local carob biodiversity conservation.
- there is an interest of farmers on carob cultivation, with also the presence of commercial carob plantations.
- farmers' consideration about carob cultivation varies by territories, based on local conditions and support mechanisms they have access to.
- cooperatives dealing with carob gathering and processing, enhance collective capacity but need training and technical assistance for effective management and market access.
- difficulty accessing markets, price fluctuations, and limited demand compared to other crops, compound the struggles of carob farmers.

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On- and off-site impacts of different land management practices related to soil health and flood control within small watersheds of Celinac Municipality in Bosnia and Herzegovina

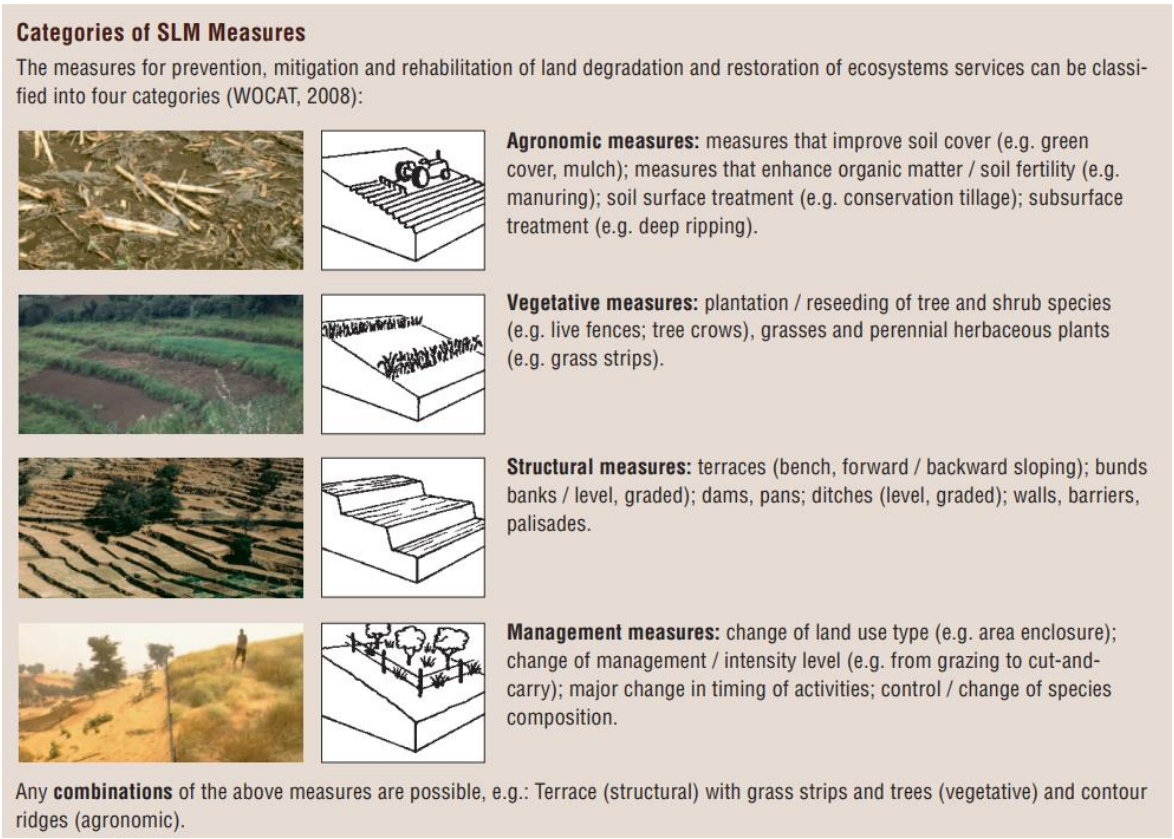
Author: Jovana ASKRABIC (Serbia)

Supervisors: H.P. Liniger (University of Bern, Switzerland),
M. Markovic (University of Banja Luka, Bosnia and Herzegovina),
P. Zdruli (CIHEAM Bari, Italy)

What were the research background and objective?

Flash floods in mountainous and hilly areas are natural hazards that cause disasters and have strong impacts on local populations and economies. These are very frequent in Bosnia and Herzegovina. On one side their frequency and intensity can be related to climate change, with increasing of heavy and concentrated rains, on the other side floods are also aggravated by mismanagement of land, like deforestation or intensive use of cropland, with soil degradation that leads to increased surface runoff and soil erosion.

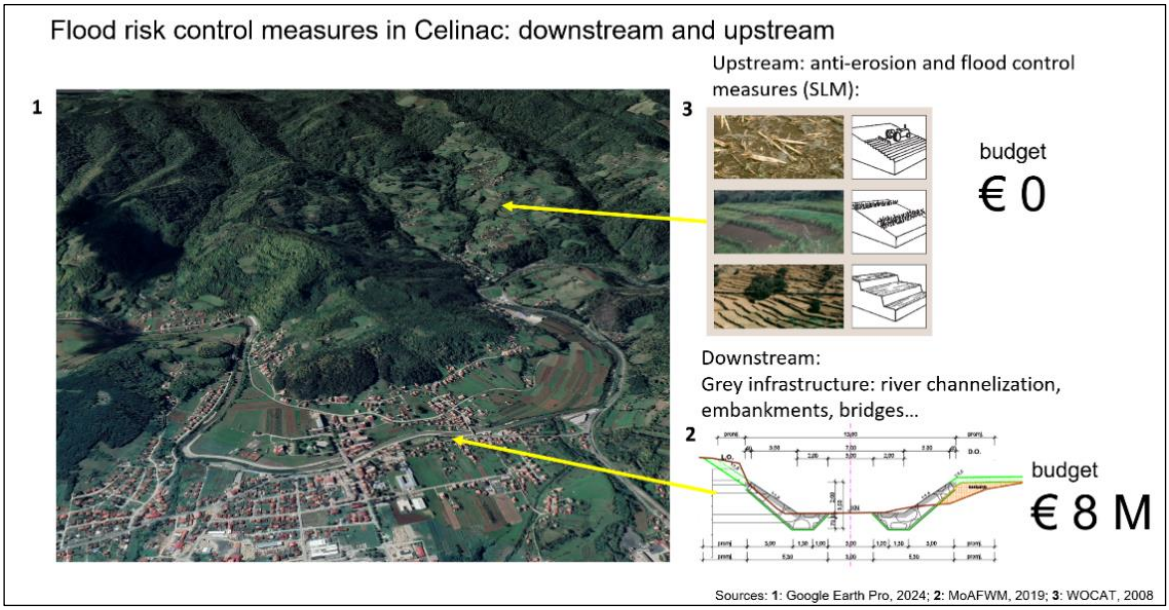
Literature suggests many Sustainable Management Measures that, often in combination, can prevent, mitigate and rehabilitate land degradation.



Categories of SLM Measures according to WOCAT

The severe 2014 floods in the Vrbas River watershed highlighted the need for a detailed study and proactive measures. In response, the Ministry of Agriculture, Forestry, and Water Management of the Republic of Srpska developed the Flood Risk Management Plan for the Vrbas River Watershed in 2019. In this plan,

Celinac municipality is identified as a high-risk zone. This includes the watersheds of the Vrbas tributaries, which have experienced significant flooding events over the past decade, and for which a mix of infrastructure measures and land use changes are proposed to mitigate flood risks.



Planned allocations for flood risk control measures in Celinac municipality

The Celinac municipality features a diverse landscape of hilly terrain, low mountains, and plains within the river valleys, supporting a population of approximately 15,000 residents. The landscape is predominantly forested, covering about 65% of the territory, while agricultural land constitutes roughly 27%. This agricultural land is primarily dedicated to maize production (68%), with additional uses including pasture and meadows (25%) and orchards (7%).

The potential of Sustainable Land Management (SLM) solutions on agricultural land is acknowledged in the flood risk management plan. However, there is a lack of detailed information on how local land management practices affect soil features, surface runoff, and soil erosion at both the field (on-site) and watershed (off-site) levels. Collecting this data is crucial to guide further research and the development of supportive policies and processes. Additionally, there is a need for detailed implementation strategies, budget allocation, and assessments of their effectiveness at both farm and watershed levels.

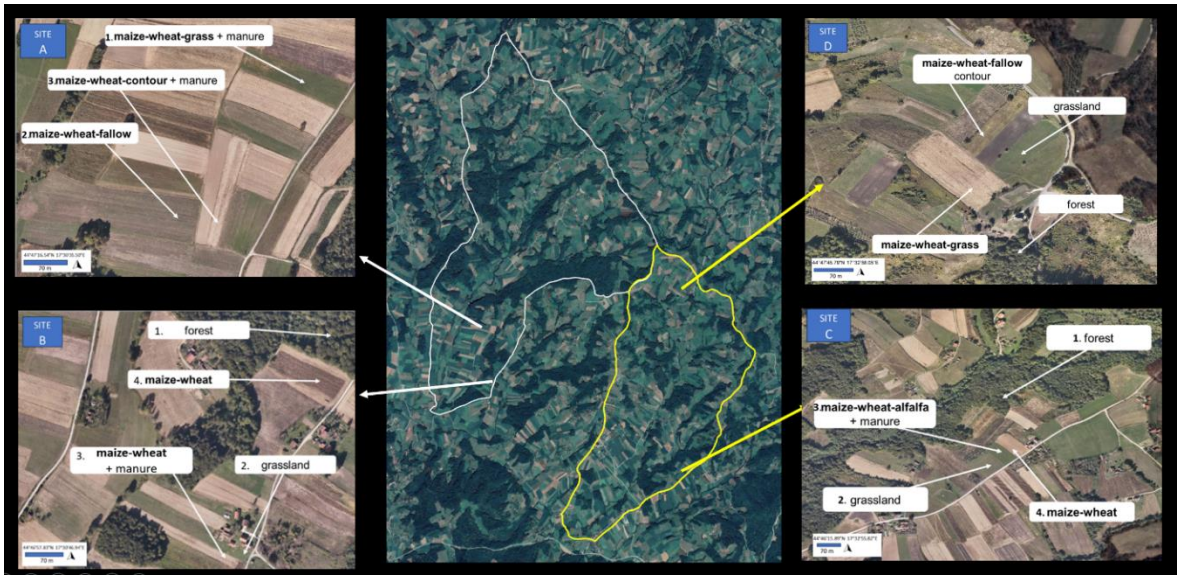
The primary objective of this study was to evaluate and link the on- and off-site impacts of different land management practices on soil health and flood control within small watersheds in Celinac Municipality, Bosnia and Herzegovina. To achieve this, the study focused on three main objectives:

1. Identify and document 3 relevant land management practices in Celinac municipality causing or reducing land degradation.
2. Assess the local impacts of identified and documented land management practices on soil health and land degradation.
3. Assess the impacts of different land management practices on surface runoff and floods at the watershed level.

How was the research implemented?

The research methodology involved a combined approach including both field and laboratory investigations, coupled with spatial analysis using GIS and hydrological modelling.

The study focused on two small watersheds Branesci (6 km^2) and Brezicani (9 km^2), located in Celinac municipality. The main criterion for their selection was the presence of agricultural land under intensive crop cultivation. The land is characterized by small, fragmented, and scattered plots with an average 0.5 ha size. Most of the farms are small, while bigger farms have 15-20 ha used for fodder production for dairy cows, including maize, small grains and grasses.



Soil health assessment: four sites and 15 treatments in Brezicani (left) and Branesci watershed (right).

Three dominant agricultural practices were selected for an in-depth analysis:

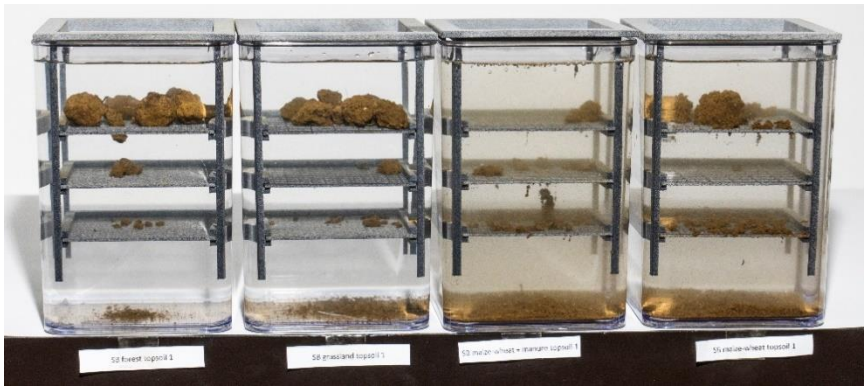
1. the conventional maize-wheat rotational system
2. maize-wheat-grass rotational system with manure application
3. maize-wheat-alfalfa rotational system with manure application

The 1st was selected since it is the most common practice used by farmers in the case study area, and potentially problematic practice for soil health. The other two were selected since these are alternative practices consisting in an improved rotation and fertilization management.

The three selected practices were documented and analysed using the WOCAT (World Overview of Conservation Approaches and Technologies) questionnaire on SLM technologies. The documentation process involved interviews with three land users, providing valuable insights into their experiences and perceptions of the different practices.

To quantify the on-site impacts, a comparative soil health assessment was conducted across different land uses/managements within the two selected watersheds. In addition to the three selected practices, the assessment included soil samples from fields with other important land management practices: maize-wheat-fallow, permanent grassland, forest, as well as maize-wheat with and without manure.

This assessment involved both field and laboratory analyses. Field assessments included visual soil analysis, evaluation of soil profiles, and water infiltration tests. Laboratory analyses included pH, organic matter content, and readily available potassium and phosphorus. Additionally, soil macroaggregate stability was assessed using a novel slake test kit prototype developed by Linger Hanspeter.

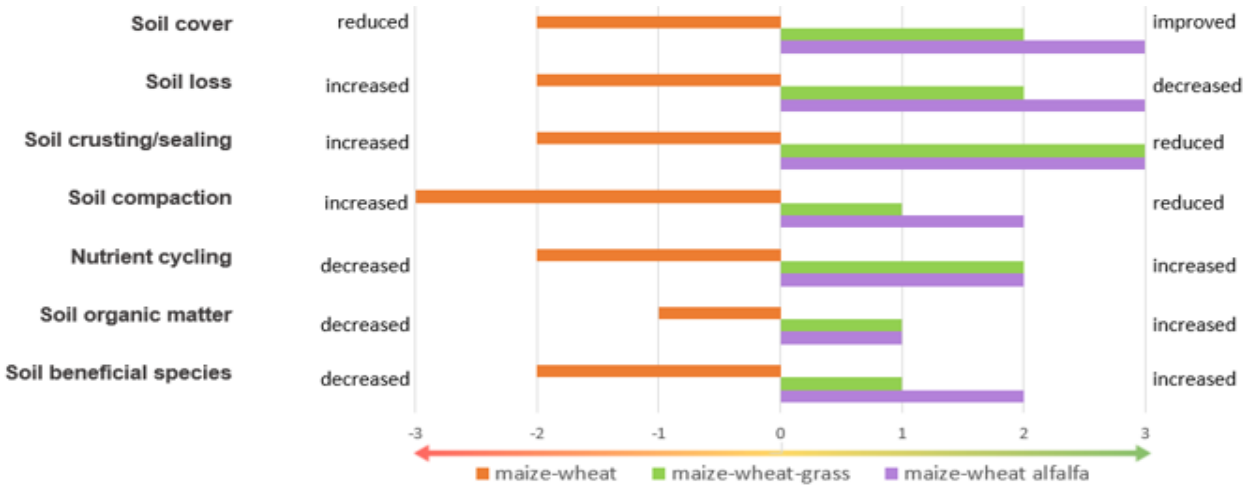


Slake test: wet macroaggregate stability in site B. Sieves with 10-, 5- and 2-mm size with soil aggregates of 15-20 mm in size immerged in water. Stable aggregates remain on top sieve (first two), while unstable aggregates disintegrate (third and partially fourth)

The second part of the research focused on the off-site impacts of land management practices, specifically on surface runoff at the watershed level. Brezicani watershed was selected based on the intensive agricultural use and contribution to flood events in the Turjanica River. The potential runoff contribution for different land use scenarios was calculated using the SCS-CN method and GIS, implemented in the SLM Watershed Tool. The analysis included three different rainfall scenarios (20 mm, 40 mm, and 80 mm) and seven land use change scenarios. These scenarios were evaluated against the current LULC map, and the resulting runoff estimates were analysed to understand the potential implications for scaling of different land management practices on the flood risk potential.

What were the main findings?

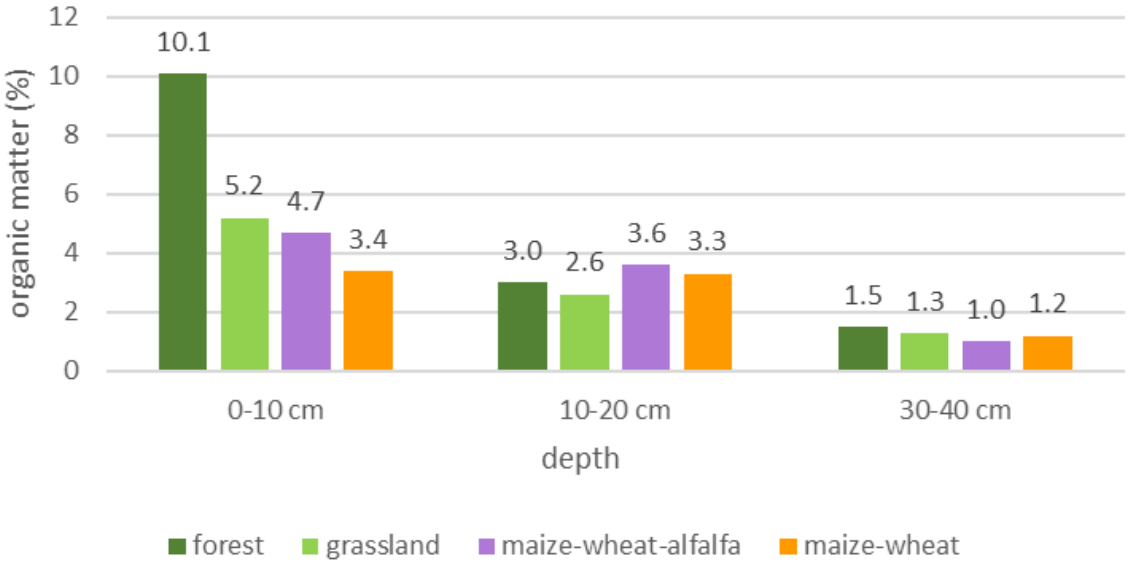
The findings from WOCAT questionnaires indicated that the common practice of maize-wheat rotation leads to long-term soil health decline. Conversely, the maize-wheat-grass and maize-wheat-alfalfa rotations, both incorporating manure application, were identified as more sustainable alternatives, based on land users' experiences. While requiring higher initial investment in the machinery, these systems improved soil structure, nutrient availability, and water infiltration, leading to better long-term yields and resilience against climate extremes.



Comparison of estimated impacts of the documented practices on soil health

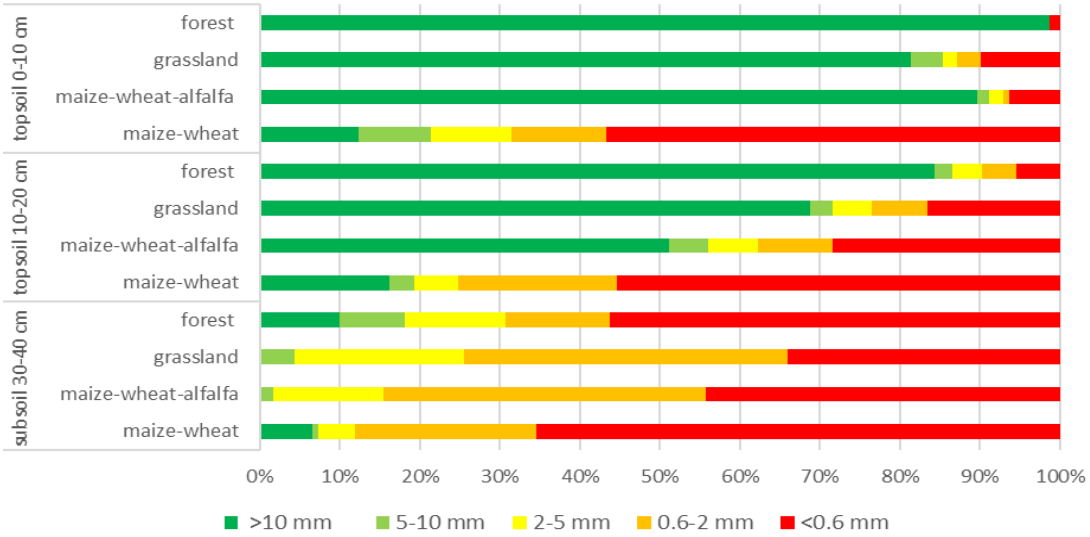
Comparison of estimated impacts of the documented practices on water cycle

The results of lab analysis in site C with Cambic Luvisol showed a clear positive impact of both grassland and alfalfa systems on topsoil organic matter. Grassland showed 5.2% organic matter, alfalfa 4.7%, and maize-wheat 3.4%, highlighting the beneficial effect of these land managements. However, at lower depths, results were not conclusive.



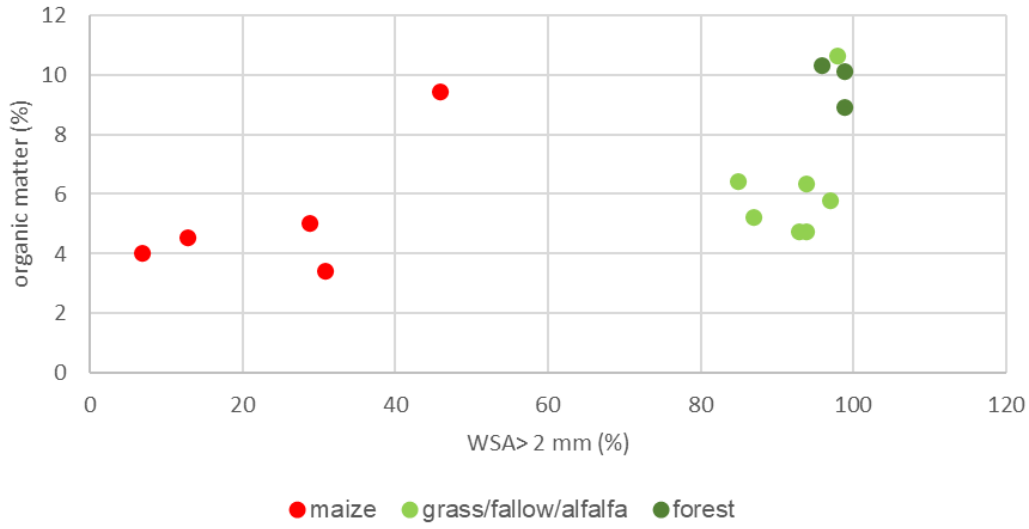
Soil organic matter, Branesci, site C

The slake test revealed that fields with good cover including forest, grassland and alfalfa had extremely high macroaggregate stability in the top 10 cm, as over 80% of the aggregates remained intact on 10 mm sieve. On the other side, maize-wheat had only around 30% of water stable macroaggregates >2 mm. The results across all four sites clearly showed that intensive maize-wheat rotation with conventional tillage significantly degraded soil structure. The study confirms that reduced tillage and good cover promote building and maintenance of stable soil structure, which is a precondition for improved infiltration and reduced runoff.



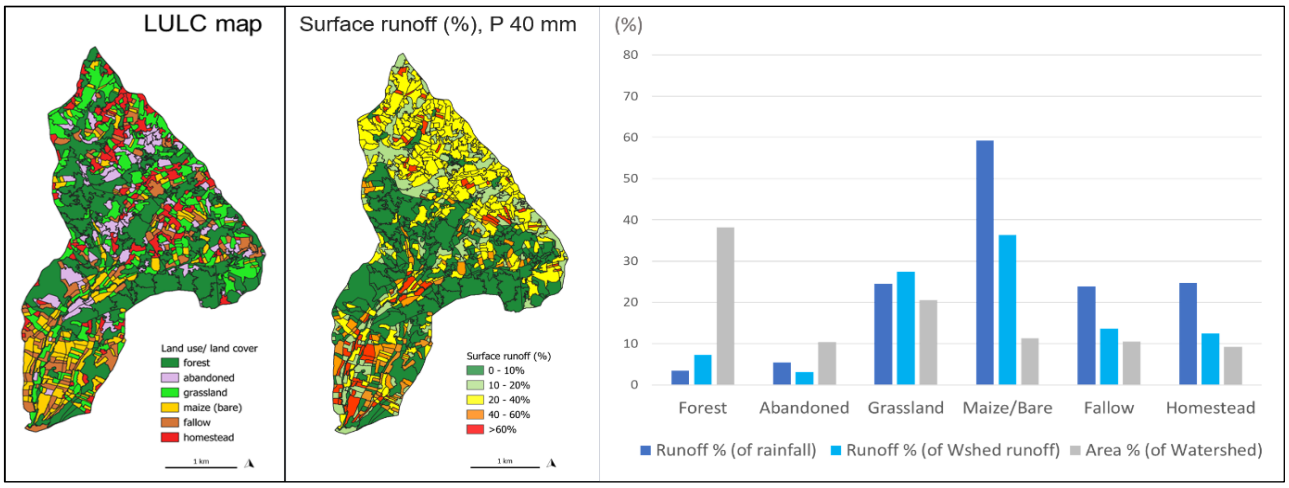
Soil Macroaggregate stability at three depths for different land managements in site C, Branesci

In general, all the topsoils were relatively rich in organic matter (> 3.4%), but not all of them had good macroaggregate stability. The graph highlights those soils with good cover and reduced disturbance consistently showed high macroaggregate stability, regardless of organic matter content. In contrast, soils on maize fields had significantly lower aggregate stability, despite their organic matter levels (3.4–9.4%). Additionally, manure alone didn't show clear positive impact on macroaggregate stability. The study suggests that while organic matter is important, continuous living cover and minimized soil disturbance are the key for the stability of soil macroaggregates.



Correlation between aggregate stability (>2 mm), organic matter and land use/cover in topsoil (0-10 cm) in Brezicani and Branesci

Analysis of surface runoff in the Brezicani watershed reveals a dynamic relationship between rainfall intensity, land use, and runoff generation. During a daily rainfall event of 40 mm, maize fields generate 60% runoff and contribute to 36% of total watershed runoff, despite covering only 10% of the area.



Contributions of land use types to runoff, Brezicani watershed, 40 mm rainfall

The results from investigations on the impact of different land use scenarios on runoff showed that during 40 mm daily rainfall events, the predicted watershed runoff varied from 6.3-32%. It is estimated that replacing bare soil with cover crops could reduce total watershed runoff by 20%, while expanding maize cultivation would increase runoff by 74%, significantly increasing the flood risk. While abandoning agriculture altogether would drastically reduce runoff (by 65%) it's not a viable solution for maintaining agricultural productivity. Instead, implementing soil and water conservation measures, as recommended by the government's Flood Risk Plan, including contour tillage, grass strips, and cover crops, have the potential to reduce runoff from maize and wheat fields by 35%. However, their implementation requires careful consideration of local conditions.

This study highlights the importance of transitioning from traditional engineering to sustainable land management approaches that enhance soil health and reduce runoff on croplands. Thus, flood risks downstream can be significantly mitigated.

In conclusion the study showed that in the study area:

- Soils with good cover and reduced disturbance showed a high soil macroaggregate stability, regardless of organic matter content, and are the areas with lower runoff and soil erosion.
- Rotation of maize-wheat systems with grasses and legumes showed a positive impact on soil health, particularly aggregate stability.
- Compared to other cropping systems, intensive maize monoculture showed significantly impaired soil health, especially regarding aggregate stability. The widespread practice of intensive maize monoculture is the most significant contributor to runoff and flooding among the cropping systems studied.

Applying sustainable land management (SLM) approaches in agricultural fields, as recommended by the Flood Risk Management Plan, is crucial for reducing flood risk within watersheds. These practices enhance soil health, reduce runoff and erosion, and ultimately mitigate flooding. Prioritizing upstream investment in SLM offers a neglected yet cost-effective and sustainable approach to flood risk reduction.

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Challenges, barriers, and determinants of farmers' adoption of agroecological practices in Tunisia: the case study of Hamam Biadha and Elles Tunisia

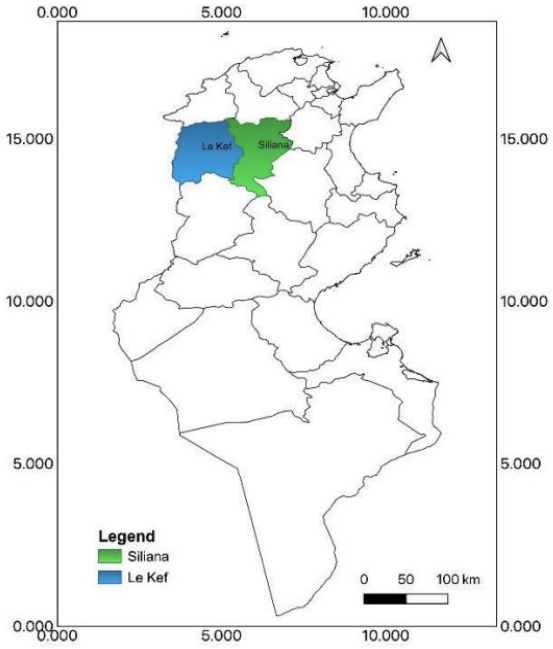
Author: Amina KHADER (Tunisia)

Supervisors: D. Boubaker (ICARDA, Tunisia), N. Driouech (CIHEAM Bari, Italy).

What were the research background and objective?

Agroecology is an applied science that, in consideration of the environmental problems, energetic crises and climate changes, has gained attention in the last decades to pursue sustainable development of agroecosystems. It utilizes ecological concepts and principles to build and manage resources, using a range of practices based on natural processes to minimize the reliance of agriculture on external inputs. These practices are frequently used by smallholders in remote areas and contribute to their food security and livelihoods.

In Tunisia, it is raising the number of organizations active in promoting the agroecological model. In the Kef-Siliana region in Northwest Tunisia, the CGIAR Agroecology Initiative (AI) has developed a so-called Agroecological Living Landscape (ALL), where smallholders manage a mixed cereal-tree-small ruminant farming system. This is an area where soil degradation and climate change are major challenges for farmers and ALL has set up a learning process with local stakeholders, in particular Farmers' Organizations, aimed at mapping the agroecological practices used by farmers and at facilitating their adoption by local communities.



The Tunisian Transect el Kef-Siliana localization in the Northwest of Tunisia

In this context, AI aims at integrating the areas of Hamam Biadha and Elles into the ALL, since these have been recognized by local stakeholders as territories with significant agroecological patterns, with many active smallholders.

Thus, the present research had as objective to survey the territories of Hamam Biadha and Elles with the main objective to explore about the present agroecological practices, and assess the challenges, barriers, and determinants for farmers' adoption.

How was the research implemented?

The research was implemented from October 2023 to February 2024 with a comprehensive methodology that, through field activities, integrated both quantitative and qualitative research tools.

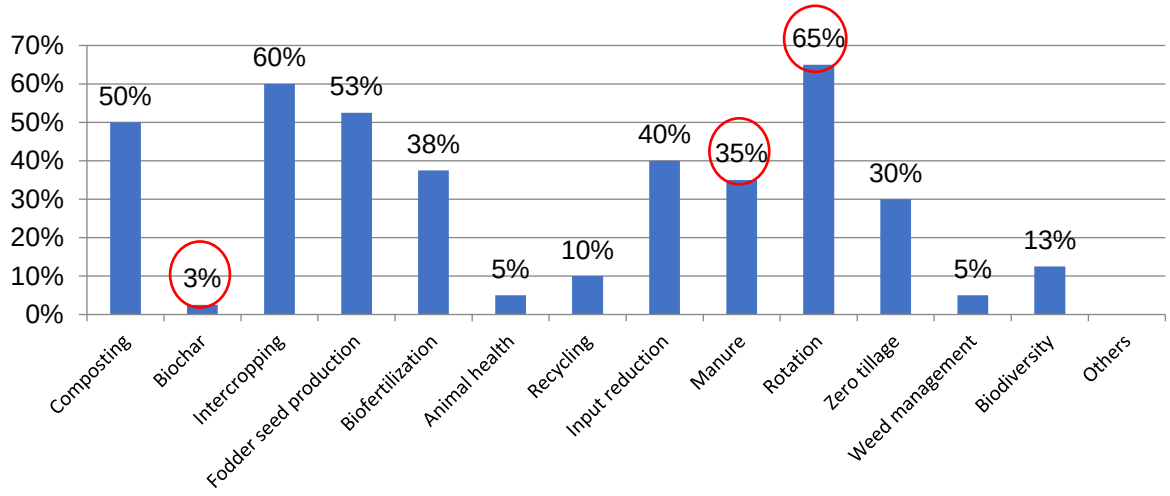
Semi-structured interviews were conducted with key informants that included researchers, practitioners, scientists, and leaders of farmers' associations. These allowed for comparative analysis and narrative summaries.

A questionnaire was also administered to farmers to understand farming systems and agroecological practices, and the drivers and constraints of adoption.

Focus group discussions (FGDs) with key stakeholders were used to explore their perceptions, attitudes, and behaviours regarding agroecological practices, providing insights into the challenges and opportunities within the farming system. A SWOT analysis was also performed to identify internal and external factors affecting the adoption of agroecological practices.

What were the main findings?

The research revealed that in the investigated area, despite nearly half of the farmers were unfamiliar with agroecological practices, certain methods are part of their field practices. The most diffused were crop rotation and intercropping, adopted by 65% and 60% of interview farmers, with composting and forage association also being prevalent.



Distribution of Agroecological Practices (%)

Significant barriers to adoption were identified, including climate change, insufficient policy support, poor infrastructure, lack of extension services, and knowledge gaps. Also, the high cost of implementing these practices and a lack of material and labour support, were perceived by farmers as hindering agroecological practices adoption. It emerged a lack of awareness and knowledge as well about the benefits and implementation of agroecological practices. Training and access to agricultural equipment were considered

drivers for agroecological practices diffusion, while illiteracy and lack of information having negative influence.

Items	SD	D	N	A	SA	Mean	Standard deviation	Decision	Mean rank	Rank
Insufficient Policy Support	0	0	0	1 (2.5%)	39 (97.5%)	1.02	0.15	High perception	4,69	2
Lack of extension services/ technical support	0	2 (5%)	0	3 (7.5%)	35 (87.5%)	1.22	0.69	High perception	5,05	4
Lack of knowledge	1 (2.5%)	2 (5%)	1 (2.5%)	5 (12.5%)	31 (77.5%)	1,425	0,9578	High perception	5,55	5
Large cultivated area	4 (10%)	10 (25%)	8 (20%)	6 (15%)	12 (30%)	2.7	1.39	Low perception	7,95	8
Lack of access to resources (Organic inputs, local seeds...)	1 (2.5%)	2 (5%)	10 (25%)	3 (7.5%)	24 (60%)	1.82	1.12	Low perception	6,34	6
Limited means of production (Machines, labor...)	1 (2.5%)	5 (12.5%)	3 (7.5%)	13 (32.5%)	18 (45%)	1.95	1.13	Low perception	6,80	7
Market access and demand (Trails...)	2 (5%)	13 (32.5%)	12 (30%)	3 (7.5%)	10 (25%)	2.85	1.27	Low perception	8,33	9
Poor infrastructure	0	0	1 (2.5%)	0	39 (97.5%)	1.05	0.31	High perception	4,70	3
Climate change (drought)	0	0	0	0	40 (100%)	1	0	High perception	4,60	1
N : 40 / Kendall's W * 0,677*** / Chi-square 243,690/ df : 9										

Farmers' perception of the barriers that hinder them from using AE practices

The study emphasized also that stakeholders recognize the importance of collective organizations, such as cooperatives, in disseminating information and facilitating adoption through social networks that share knowledge and resources among farmers.

It was concluded that:

- despite a relatively low integration of agroecology in the agricultural systems of Hamam Biadha and Elles, there is significant potential for improvement.
- traditional agroecological practices such as crop rotation, intercropping, and composting are diffused, reflecting a historical reliance on mixed farm systems that combine cereal-tree-small ruminant farming.
- substantial barriers for agroecological practices adoption by farmers are drought, resource access constraints, and market-related factors being the primary impediments.

The adoption of agroecological practices has the potential to improve household incomes, reduce poverty, and enhance productivity. However, an agroecological transition requires supportive policies, investment in training, and resources to facilitate the adoption of agroecological practices. What is needed is the development of a supportive stakeholder framework, in particular building capacities on agroecological approaches of farmers' organizations, to mobilize local communities. The creation of a specific label or certification for main local products, particularly in the olive oil sector, could enhance local products value and motivate farmers' engagement.

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