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EDITED BY
Anas Hamdani,
National Institute for Agricultural Research (Morocco), Morocco

REVIEWED BY
Amine Benmehaia,
University of Biskra, Algeria
Abram Bicksler,
ECHO, Inc., United States

*CORRESPONDENCE
Inès Zouari
ines.zouari@inat.ucar.tn

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Between agroecological objectives and political realities: governance, structural constraints and trade-offs of transition in Tunisia

Inès Zouari[1]*, Salma Jallouli[1], Rita Jalkh[2,3], Haïfa Benmoussa[4], Youssef Trifa[1], Sawsen Ayadi[1], Mélanie Requier[2,3] and Mehdi Ben Mimoun[4]

[1]Laboratory of Genetics and Cereal Breeding LR14AGR01, National Institute of Agronomy of Tunisia, University of Carthage, Tunis, Tunisia, [2]CIHEAM-IAMM, UMR SENS, Montpellier, France, [3]SENS, Univ Montpellier, CIRAD, IRD, Univ Paul Valery Montpellier 3, Montpellier, France, [4]Laboratory GREN TEAM LR17AGR01, National Institute of Agronomy of Tunisia, University of Carthage, Tunis, Tunisia

This paper explores the policy framework and the structural barriers that shape Tunisia's transition to agroecology. The study builds on an analysis of strategies recently issued by the Ministry of Agriculture, Hydraulic Resources and Fisheries and the Ministry of Environment, complemented by a literature review, and insights from farmers collected from participatory workshops conducted under the NATAE project's Living Lab in Siliana. Eleven strategies were selected and analyzed to identify explicit mention of agroecology and references to the 10 FAO elements of agroecology. For each element, the degree of integration within agricultural and environmental strategies was assessed. While only six strategies explicitly mention agroecology, agroecological FAO elements are embedded in all of them, reflecting the State's increasing commitment to integrating this approach into its development agenda. Despite this awareness, several barriers hinder the effective transition. These include compartmentalized and disconnected policy visions, institutional weaknesses, and the exclusion of farmers from the decision-making process. Furthermore, the prioritization of food self-sufficiency policies, coupled with land tenure challenges and financial limitations, constrain the implementation of agroecology. The findings highlight a paradox: despite a long history of agroecological initiatives and a growing acknowledgement of agroecology within national strategies, adoption remains limited in practice. The study argues that coherent policy integration, inclusive governance mechanisms and strengthened financial support to farmers are essential to overcome these barriers and to foster agroecological transition in Tunisia.

KEYWORDS
agricultural and environmental strategies, agroecological transition, barriers, FAO 10 elements of agroecology, policy framework, participatory workshops, farmers, Tunisia

1 Introduction

Agroecology has been conceptualized in various ways, consistently associating ecology and agronomy (Altieri, 1989; Francis et al., 2003; Gliessman, 2007). Over time, the concept has progressively expanded to encompass broader processes related to the transformation of food systems (Gliessman, 2013). At the same time, the concept has never been purely technical or scientific but deeply imbued with social and cultural values (Altieri, 1989; Francis et al., 2003; Gliessman, 2013). Gliessman (2007) reflected the holistic and transformative nature of agroecology when he defined its goal as "the transformation of food systems toward sustainability where there is a balance between ecological soundness, economic viability, and social justice". Wezel et al. (2009) further emphasized the transdisciplinary nature of agroecology when he defined it as a scientific discipline, a set of agricultural practices, and a social movement. In his paper, he found that the emergence of agroecology was generally driven by a strong emphasis on one of these three dimensions- science, practice, or social movement even if, currently, all of them coexist and still evolve. For instance, in the United States and Germany, agroecology, first, emerged in the 1930s as a scientific discipline while, in Brazil, agroecology foundations lie in social movements, which appeared in the 1970s, in relation with traditional agricultural practices. The case of France is different as agroecology initially emerged as an alternative agricultural practice, focusing on ecological farming techniques (Wezel et al., 2009).

The origins of agroecology in Tunisia probably date back to traditional farming systems in which farmers applied ecological principles such as water harvesting, soil conservation, (Jebari et al., 2015), mixed farming practices and crop diversification (Santoro et al., 2020), long before the introduction of the term "agroecology." The Ramli cropping practices in Ghar El Melh-where crops are grown on sandy substrates in the lagoons and fed by rainwater stored above seawater, influenced by tides- are a striking example of traditional ingenuity in managing scarce land and water. These unique farming systems, created in the 17th century, have been recognized, together with the hanging gardens from Djebba El Olia as Globally Important Agricultural Heritage Systems (GIAHS), in 2020 (FAO, 2020). An earlier recognition was granted for Gafsa oases, in 2011, considered as hotspots of traditional farming practices, relying on multi-layered cropping and community management of water resources (GIAHS, 2012).

Conservation agriculture, as a farming system that promotes sustainable agriculture by maintaining a permanent soil cover, minimizing soil disturbance, and diversifying crop species, is largely inspired by the principles of agroecology (De Schutter, 2010). Conservation agriculture associated with no tillage started to be implemented in Tunisia more than 50 years ago in the framework of a research-development project funded by the United States Agency for International Development. The real breakthrough came later in 1999 through a multitude of projects, involving multiple national and international research and development institutions and supported through international funding. Most of these projects targeted smallholder farmers and were conducted in Siliana and Kef, particularly affected by soil erosion and degradation (M'Hamed et al., 2019).

In recent years, a rising number of large-scale projects have been implemented by international organizations in partnerships with the Ministry of Agriculture, Water Resources and Fisheries (MARHP) and the Ministry of Environment (ME). At the same time, these ministries began integrating agroecological principles into their strategies, likely driven by (i) the gradual degradation of natural resources due to anthropogenic activities, (ii) the demonstrated high vulnerability of natural resources to climate change (iii) the farmers' social and financial precarity and (iv) the State's commitment to align its priorities with international sustainability agendas. The latter mainly consists of the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement to which Tunisia is a signatory (Republic of Tunisia, 2021) as well as engagement in dialogs with international organizations such as the Food and Agricultural Organization of the United Nations (FAO) on agroecological transitions (FAO, 2018). This growing engagement could also be due to the estimated economic cost of climate inaction (mainly on water shortages, coastal erosion, and flooding shocks), projected to reduce real GDP by 6.4% by 2050 (~TD 10.4 billion) (RCP 8.5 scenario). The agricultural sector would be particularly affected with value-added declining 29% by 2050 (World Bank, 2023a).

In recent years, the Tunisian agriculture has been facing concurrent crises, including (i) the climatic constraint, and mainly the succession of years of drought associated with long periods of heat, sometimes reaching historical records (ii) the Covid-19 health crisis and its serious consequences on the global and national economy and (iii) the food crisis resulting from the war in Ukraine which led to disruptions in wheat production and trade with the decrease in the quantities traded and the rise in prices (World Bank, 2023b). This last shock has been particularly acute for Tunisia, given that about 60% of the wheat consumed in Tunisia comes from Ukraine and Russia. Unsurprisingly, the combination of these shocks has created significant uncertainty across the agricultural sector with severe impacts on food security, farmers' income and rural employment (Mahjoub and Belghith, 2022; African Development Bank, 2023).

In response to these crises, the MARHP placed more focus on achieving self-sufficiency particularly in durum wheat as a short-term priority. To this end, it launched initiatives aimed at increasing local production and productivity. These programs include raising farm-gate prices, expanding irrigated areas and subsidizing irrigation water and equipment (USDA, 2023). While these measures are effective in enhancing short-term yields, they diverge from the principles of sustainability and agroecology, creating a gap between immediate objectives and the long-term goals of sustainable resource management. In addition to these measures, some technical, financial, structural and institutional barriers, deeply embedded within the agricultural development model, continue to constrain the adoption of sustainable and agroecological practices (Ben Bechr, 2016). These reflect the state's vision of agricultural development, which has led to choices such as the adoption of the agronomic package introduced by the Green Revolution and the state's disengagement from its role of providing guidance and support to farmers (Elloumi, 2018). It has also been withdrawn from addressing certain historical issues responsible for farmers' precarious situation, including land tenure systems, inheritance rules, land fragmentation, and limited access to credit.

Here is the correct sentence: Taken together, these elements highlight a critical gap between the policy discourse on agroecology and on-the-ground realities. This gap constitutes the central focus of this study. Accordingly, we analyzed the agricultural and environmental policy orientations with respect to agroecology, while addressing the following main question: To which extent Tunisia's agricultural and environmental policies integrated agroecological principles and what factors hamper their effective adoption on the ground?

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With this aim, three parts were elaborated. The first one is an overview of the past and present priorities in Tunisian agricultural policies, with focus on the evolution of food security, sustainability, and climate adaptation objectives within the country's agricultural development model. The second part is a review of ongoing strategies recently released by the MARHP and the ME to identify the extent to which agroecology is integrated within them. In the last and third part of the paper, we discuss the barriers existing to the adoption of agroecology based on literature review, and participatory workshops with farmers conducted under the NATAE project (*Fostering agroecology transition in North Africa through multi-actor, evaluation and networking*) Living Lab in Siliana (NATAE, 2023).

2 Methodology

The first part is a historical review of Tunisia's national agricultural policy with focus on the evolution of food security, sustainability, and climate adaptation objectives in the Tunisian agricultural development model. Primary sources included the Five-Year Economic and Social Development Plans, official policy documents from the Ministry of Agriculture, and environmental institutions. Secondary resources such as peer-reviewed literature and international reports on national agricultural orientations and policies were also consulted.

The second part was dedicated to the integration of agroecology in the ongoing agricultural and environmental strategies. To this end, an initial inventory was conducted on the policy documents addressing agricultural and environmental topics released since 2015. The FAOLEX database on national policy and legal frameworks was consulted to ensure the completeness of the inventory (FAO, 2025). Following this, we retained only national strategies led by the MARHP and the ME in Tunisia and whose implementation period was still ongoing at the time of the study.

To ensure a coherent and systematic assessment of agroecology across policy documents, the analysis relied on the FAO's 10 elements of agroecology as an operational analytical framework (FAO, 2018).

These elements-Diversity, Co-creation and sharing of knowledge, Synergies, Efficiency, Recycling, Resilience, Human and Social Values, Culture and food traditions, Responsible governance, and Circular and solidarity economy-provide a widely recognized and policy-oriented reference for assessing the integration of agroecological pillars.

A screening process was performed to identify strategies that either explicitly mention agroecology or address at least two of the 10 agroecology elements as well as their associated keywords and concepts reflecting their scope as defined by the FAO (FAO, 2018). The adoption of the threshold of at least two elements (out of the 10 defined by the FAO) was a methodological choice aimed at ensuring a minimal level of alignment with the FAO agroecology framework, while at the same time avoiding the identification of strategies which make only an incidental mention of an isolated element of agroecology, without covering a broader dimension. A higher threshold would have been overly restrictive, leading to the exclusion of strategies that are relevant to the scope of our analysis.

An in-depth analysis of the identified strategies was then conducted in two main steps. First, we coded the presence of the FAO elements or associated keywords and concepts reflecting their scope as defined by the FAO (FAO, 2018), using a binary system (presence/absence). Second, we examined the proposed actions in relation to each element in order to assess the vision of the Ministry regarding the operationalization of the element. All elements were treated equally in the analysis, without applying weight, as the objective was to assess their representation and interpretation within the policy framework rather than to quantify their relative importance.

Finally, the third part aimed to identify and discuss the barriers to agroecology implementation through a mixed-method approach. This analysis combined (i) conclusions drawn from the analysis of the strategies conducted in the second part, (ii) a review of scientific and institutional literature examining the structural, economic and policy dimensions influencing the agroecological transition in Tunisia and comparable contexts and (iii) a qualitative data gathered from two workshops with stakeholders and farmers to capture on-the-ground perceptions of agroecology and barriers to its implementation.

These workshops were organized in the framework of the Living Lab activities on cereal plains in Siliana (Tunisia), under the NATAE project. The first workshop, held on April 18, 2024, brought together 20 stakeholders, including farmers, researchers, representatives from public institutions and a farmer syndicate representative. This workshop focused on identifying the main factors affecting the food system and limiting the agroecological transition in the region. Using an iceberg model, the participants identified the visible events affecting the agricultural system and the transition process and collectively reflected on the deeper and more structural factors that influence them. The process was conducted through facilitated discussions in which the model was progressively drawn and completed with participants' inputs to obtain an iceberg structured in 4 layers, composed of: (i) surface events affecting the agroecosystem, (ii) patterns, processes, and system functions that could explain these events and lead to influence the dynamic of the system, (iii) the systemic structures shaping these dynamics, including policies, laws and governance rules and (iv) the underlying paradigms, values, and worldviews that influence how resources are managed and decisions are made.

The second workshop was held on May 23, 2024, and gathered 18 farmers. This workshop aimed to evaluate potential agroecological practices for implementation at farm levels and to identify the barriers hindering their adoption. Small-group discussions were facilitated to assess the feasibility of six practices: no-till sowing, crop rotation, livestock activities, fodder association, intercropping, and reduction of chemical inputs, identified through territorial diagnosis and multi-stakeholder workshop, conducted in the framework of the project. In both workshops, notes were collected to gather all contributions and identify consensus and divergent points of view.

3 Results

3.1 Overview of past and present priorities in national agricultural policies

The general orientations of the Tunisian governments in the agricultural sector are outlined in the Five-Year Economic and Social Development Plans, which are designed to shape the country's economic and social growth over a five-year period.

Food security has been at the heart of the national agricultural strategies. It has been introduced during the elaboration of the seventh national

development plan (1987–1991) (Laajimi et al., 2012) and aimed at achieving self-sufficiency in certain staple products including durum wheat, bovine meat, milk and poultry products. It also aimed at increasing exports of products that guaranteed a certain competitivity for Tunisia on the international markets (olive oil, seafood, dates, and citrus and organic products). With this aim, Tunisia embarked on structural reforms supported by the Agricultural Sector Adjustment Program (PASA) which are meant to also contribute to improving the country's balance of payments and improve its public finances, while ensuring the creation of employment opportunities. The reforms focused mainly on the development of irrigated farming, promotion of irrigation efficiency, sustainable resource use, and technological innovation to conserve water.

The 8th Plan (1992–1996) strengthened productivity through investments in agricultural research, extension services, land, agricultural credit and budgetary reforms to encourage private entrepreneurship. In the late 1990s, Tunisia sought greater integration into global market, notably through an agreement with the European Union, joining the World Trade Organization liberalization, and participating in the Arab free trade area. This led to reforms in price policies, reductions in subsidies, and the liberalization of prices for many products, although the prices of durum wheat and bread wheat remained fixed. Tunisia also continued pursuing its objectives of self-sufficiency in several agricultural products including cereals, tomatoes, milk and red meat (World Bank, 2006).

The subsequent plans built on the achievements of previous ones, with continued efforts focused on strengthening food security as a foundation of national sovereignty, enhancing the competitiveness of the agricultural sector, and promoting exports as a key driver of growth. They also emphasized the sustainable management of natural resources and, more recently, the adaptation of production systems to climate change (FAO, 2013; IFAD, 2016).

In 2023, a development plan (2023–2025) was elaborated in a context of crises related to geostrategic perturbations engendered by the Russian-Ukrainian war and the COVID-19 economic impacts. In this plan, a clear commitment was made to align to the sustainable development goals in all the sectors and to promote sustainable and inclusive agriculture that supports the development and enhances the water and food security (Republic of Tunisia, 2023).

In the Environmental sector, Tunisia has been a pioneer among Arab and African countries in establishing institutions dedicated to environmental protection, notably through the creation of the National Commission for Sustainable Development (CNDD) in 1993, an inter-institutional body responsible for integrating sustainable development principles into the national strategy. In addition, the Tunisian Observatory for the Environment and Sustainable Development (OTEDD) was set up within the National Agency for Environmental Protection. The OTEDD serves as the national dashboard for monitoring sustainable development activities (ME, 2022a).

Tunisia has also acceded to all multilateral conventions and treaties related to environmental protection and sustainable development (ITES, 2016) and is engaged in integrating the international agendas in its plans. For instance, Tunisia expressed its commitment to implement the Sustainable Development Goals (SDGs) of the United Nations and started with the adoption of the first post-revolution development plan (2016–2020).

In accordance with its commitment under the Paris Agreement on climate, Tunisia submitted its Nationally Determined Contribution (NDC) in 2021. This multisectoral and national document aimed to enhance Tunisia's mitigation of greenhouse gas emissions by raising its target for the reduction of national carbon intensity to 45% by 2030 compared to its 2010 level. In terms of adaptation, the overall goal of the updated NDC is to "promote a climate-resilient Tunisia, significantly reducing vulnerabilities and strengthening the adaptation capacities of its ecosystems, population, economy, territories, and having resolutely carried out the necessary transformations to ensure an inclusive and sustainable socio-economic development model". Furthermore, the update of the adaptation section of the NDC incorporates three new cross-cutting dimensions: gender, land-use planning, and disaster risk reduction (Republic of Tunisia, 2021).

3.2 Agricultural and environmental strategies, visions and objectives

The initial inventory identified 26 documents addressing agricultural and environmental topics released since 2015, including strategies, actions plans and programs. Out of these, documents that were not officially led by the MARHP and ME and whose implementation period has expired were discarded. Subsequently, among the retained strategies, 11 either made an explicit reference to agroecology or mentioned at least two of the FAO agroecology elements and were therefore selected for in-depth analysis. Of these, three strategies were released by the MARHP, seven by the ME and one was jointly developed by both ministries (Table 1).

The MARHP's performance project (PAP) is released annually and outlines the agricultural development policy over the medium term. The 2024 project objectives are aligned with the 2023–2025 Development Plan long-term vision: "A sustainable, inclusive agriculture that supports development and strengthens water and food security" and with the Tunisia's commitment to the Sustainable Development Goals (SDGs) by 2030 (MARHP, 2024).

The project focuses on (i) rationalizing the use of resources, protecting landscapes and biodiversity, mitigating the effects of climate changes and preserving of the agricultural systems' sustainability, (ii) giving priority to investment promotion (iii) modernizing and digitalizing the agricultural sector and (iv) improving income levels of farmers through the adoption of a comprehensive and inclusive development approach particularly for small farmers, youth, and women in rural areas (MARHP, 2024).

In the context of current climate change that led to the scarcity of water resources in the country, national strategies have been elaborated to strengthen resilience in the agricultural sector. The Drought National Plan (PNS) was jointly developed by the MARHP and ME and supported by the MARHP/ME, 2020. The PNS aims to improve water management, coordinate institutional responses, and support adaptation measures for farmers facing drought. Complementing this, the MARHP has developed Water 2050, a water sector strategy (MARHP, 2022). This strategy aims to preserve water resources, promote the use of non-conventional water sources such as treated wastewater, enhance water use efficiency and further modernize irrigation systems used by farmers.

Still in the context of sustainable and climate-resilient management of natural resources, the General Directorate for Agricultural Land Development and Conservation (DGACTA) of the MARHP had set up a strategy for the development and conservation of agricultural land by 2050 (MARHP/DGACTA, 2017). In addition to its cross-cutting objectives aiming essentially to strengthen the territorial governance and address the challenges in disadvantaged rural areas, this strategy also included technical orientations that sought to better manage the natural resources and promote the agroecological practices in the marginal and cereal producing areas.

TABLE 1 Main ongoing national strategies released by the MARHP and the ME.

Ministry	Strategy	Program/Partner organism	Year of release
MARHP	Strategy for the Development and Conservation of Agricultural Lands (ACTA) by 2050	European Union	2017
	Development of the Vision and Strategy for the Water Sector by 2050 for Tunisia (Water 2050)	KFW/GIZ	2022
	Annual Performance Project for the Programs of the Agriculture, Water Resources, and Fisheries Missions for 2024 (PAP 2024)	-	2024
ME	Sustainable Development Strategy for Oases in Tunisia (SDDOT)	World Bank	2015
	National Strategy and Action plan for Biodiversity 2018–2030 (SPANB)	United Nations Development Program (UNDP)	2017
	National Action Plan on Sustainable Production and Consumption Patterns in Tunisia 2016–2025 (MCPD)	Switch Med Program/European Union	2016
	National Action Program to Combat Desertification 2018–2030 (PAN-LCD)	Global Environment Facility (GEF)/United Nations Environment Program (UNEP)	2020
	National Carbon Neutral Development Strategy – Resilient to Climate Change (SNBC&RCC)	GIZ	2022
	National Ecological Transition Strategy-2050 (SNTE)	United Nations Development Program (UNDP)	2023
	National Strategy for Global and Sectoral Circular Waste Management (SNGC-GSD)2035/2050	-	2023
Joint MARHP - ME	National Drought Plan (PNS)	United Nations Convention to Combat Desertification	2020

Also, in line with sustainable development, and in the context of climate change, the ME published a document in 2022 summarizing the National Low-Carbon Strategy (SNBC) and the National Strategy for Climate-Resilient Development (SNRCC) (ME, 2022b). The sectoral axes listed within the document relating to agriculture, natural resources and ecosystems were mentioned to aim to:

- Promote climate-resilient and remunerative agriculture that respects ecological balances
- Transform the fisheries sector to ensure sustainable food security
- Improve biodiversity governance while providing actors with decent incomes
- Limit the impacts of climate change on water resources and transform the management model to meet water needs.

The National Action Plan to Combat Desertification (PAN-LCD) developed by the ME in 2020 is aligned with the 2018–2030 Decennial Strategic Framework of the United Nations Convention to Combat Desertification (UNCCD) and aimed to achieve land degradation neutrality (LDN) and strengthen ecosystem resilience to climate change. This action plan has the following main objectives listed: (i) Protect land and ecosystems from erosion, salinization, and limit conversion into agricultural land, (ii) Restore degraded lands and affected ecosystems, (iii) Enhance the resilience of agro-systems and ecosystems to climate change impacts and (iv) Improve living conditions and promote sustainable rural territories.

A strategy that is connected to efforts to combat desertification is the National Strategy and Action Plan for Biodiversity (SPANB) (ME, 2017). It aims to develop a national biodiversity that will be "resilient to climate change, safeguarded from threats, and conserved and managed in a way that contributes sustainably to the country's socio-economic development". In this context, the sustainable use of biodiversity aims to ensure that the value of its goods and services is preserved for both present and future generations.

Unlike other strategies focused mainly on production, the National Action Plan on Sustainable Production and Consumption Patterns in Tunisia 2016–2025 (MCPD) (ME, 2016) also addresses consumption patterns and aims to ensure a sustainable food chain that improves economic, social and environmental performance throughout the life cycle of the product. This vision is part of an approach that strives to ensure food security, limit overexploitation of resources and set up sustainable production and consumption patterns.

In another context, the Sustainable Development Strategy for Oases in Tunisia (ME, 2015) stands by targeting one farming system: the oases. The actions proposed in this plan aim to deeply transform the structure of oasis areas and to ensure sustainable territorial development. The natural, economic, social, and cultural heritage they represent makes them capable of effectively combating climate change, desertification, aridity, and their related ecological, economic, and social impacts.

Another recent and complementary initiative in Tunisia's environmental domain is the National Strategy for Global and Sectoral Circular Waste Management (ME, 2023a). This strategy aims to promote the principles of circular economy across sectors by improving resource efficiency, promoting recycling and waste valorization, and reinforcing governance.

In the same year, Tunisia released its most cross-cutting strategy, the National Strategy for Ecological Transition (ME, 2023b) that outlines the country's orientations in the field of the environment. This strategy is based on the concepts of environmental protection,

sustainable development, adaptation and resilience to the effects of climate change in all sectors of economic and social development.

3.3 Place of agroecology in the agricultural and environmental strategies

In this section, we inspect the agricultural and environmental strategies to identify the place that agroecology occupies from the institutional point of view. Among the 11 strategies studied, six explicitly mentioned the term agroecology. The FAO's 10 elements of agroecology were, however, strongly present in all the analyzed strategy documents, thereby demonstrating the State's growing interest and commitment in integrating this approach into its policies (Table 2). To provide a visual illustration of the relative integration of each agroecology element in the MARHP and ME strategies, a radar chart was prepared (Figure 1). This radar shows the proportional coverage of FAO agroecology elements and the main actions related to each element. For each ministry, the percentage of strategies addressing each element was calculated by dividing the number of strategies that include the element by the total number of strategies from that ministry and multiplying by 100.

Agroecology was only defined in the SNTE as "an agriculture that goes beyond organic farming and draws inspiration from agroforestry, in order to ensure food security, social inclusion, and the sustainability of natural capital elements: soil, water, forests, and ecosystems" (ME, 2023b). In this strategy, agroecology is depicted as a method to ensure the sustainable management of natural resources and ecosystems that need to be preserved, restored and regenerated. Yet, when the term agroecology was mentioned, reference was made primarily to on-farm agroecological practices aiming at preserving or restoring natural resources and soil in particular (for example revegetation, no-till sowing, agroforestry), while overlooking off-farm practices that contribute to the wider socio-economic dimensions of agroecology.

On the other hand, the strategies unanimously concurred on the necessity of integrating co-creation in the design and implementation of policies and on improving the governance performance. Co-creation guarantees the active involvement of the various stakeholders including institutional actors, the private sector, NGOs, and local communities. This inclusive approach ensures a context- specific solution design and facilitates their effective adoption. In this context, the strategies emphasized the importance of strengthening the dialog with all stakeholders and providing training for representatives from ministries, public institutions, and local authorities (ME, 2023b, SNTE). They also highlighted the necessity of adopting the bottom-up approaches to build trust between the local communities and the State's representatives and to guarantee the successful implementation of initiatives (ME, 2015, SDDOT; MARHP/DGACTA, 2017, ACTA; ME, 2017, SPANB; ME, 2020, PAN-LCD; MARHP/ME, 2020, PNS). There is therefore a clear need to evolve toward new intervention methods, that guarantee a greater participation of the local actors, and which consider farmers as partners and not just as beneficiaries (MARHP/DGACTA, 2017, ACTA). Sharing of knowledge was promoted through the valorization and diffusion of local know how of farmers and local communities (ME, 2015, SDDOT; ME, 2020, PAN-LCD; ME, 2016, MCPD; ME, 2022a, SNBC and RCC; MARHP/ME, 2020, PNS), reinforcement of extension services provided for farmers (MARHP/DGACTA, 2017, ACTA; ME, 2020, PAN-LCD; MARHP/ME, 2020, PNS; MARHP, 2022, Water 2050; ME, 2022a, SNBC and RCC) support and strengthening of research-development systems (ME, 2015, SDDOT; ME, 2017, SPANB; MARHP/ME, 2020, PNS; ME, 2020, PAN-LCD; ME, 2022a, SNBC and RCC; ME, 2023b, SNTE; MARHP, 2024, PAP) and better integration of topics like ecology, sustainability and agroecology in education systems (ME, 2016, MCPD; ME, 2022a, SNBC and RCC; ME, 2023a, SNGC-GSD; ME, 2023b, SNTE).

In parallel, the establishment of more responsible and inclusive governance that enhances the capacity of public institutions in managing and preserving resources and strengthens regional decision-making was considered as essential in all the strategies. Several measures were proposed to achieve this goal, such as administrative restructuring, creation of new authorities and dedicated funds, establishment of support units for investors engaged in sustainable resource management, strengthening of local and regional authorities, among others. Together, these measures aim to enable the design of more tailored solutions that take into consideration the specificities of different regions.

There were also references to human and social values in all the strategies. Explicit commitment was mentioned regarding the integration of gender perspectives through a multitude of actions. These mainly include (i) strengthening women capacities and involvement in all phases of the participatory rural development process, (ii) promoting and supporting rural women agricultural and off-farm income-generating activities (ME, 2020, PAN-LCD), (iii) providing training and support for youth and women in creation of sustainable jobs (ME, 2023b, SNTE), (iv) encouraging investment led by rural women, (v) creating women cooperatives for artisanal products (ME, 2015, SDDOT), (vi) achieving parity in all consultations, governance bodies and decision making (MARHP, 2024, PAP) and (vii) protecting farmers against drought risks (MARHP/ME, 2020, PNS).

Additionally, several strategies acknowledged the importance of small-scale and family farming in Tunisia and the challenges it faces. These strategies recommended a set of solutions such as the promotion of farmers organization into groups (ME, 2016, MCPD; MARHP/DGACTA, 2017, ACTA; ME, 2020, PAN-LCD; MARHP, 2022, Water 2050; ME, 2022a, SNBC&RCC; MARHP, 2024, PAP), the easing of access to credit for small-scale farmers and the development of short marketing channels with lower transaction costs and the enhancement of the position of farmers within the value chain (ME, 2016, MCPD).

Resilience was a recurring theme across all strategies. In the SNBC&RCC (ME, 2020), the vision for agricultural resilience is articulated as follows:

"*A sustainable and climate-resilient agriculture that ensures food security, improves the governance of natural resources, protects its water and land capital, and secures the livelihoods of stakeholders*". Resilience therefore seems to be closely linked, unsurprisingly, to the addressing of the impacts of climate change and particularly to the recurring urgency of food security. It also emphasizes adaptation measures for vulnerable populations, women and ecosystems. In fact, the strategic orientations clearly reflect the influence of international frameworks, in line with Tunisia's commitment to the 2030 Sustainable Development Goals (SDGs) (MARHP, 2024, PAP).

Most strategies incorporated these core elements of resilience to varying degrees, outlining actions such as enhancing biodiversity, improving soil fertility, boosting the role of ecosystems in carbon storage, and conducting awareness campaigns to foster environmental knowledge and shift behaviors toward the protection of biodiversity and ecosystems.

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TABLE 2 Alignment of the strategies studied with the FAO elements of agroecology (√: element addressed, empty cells: element not addressed).

Ministry	Strategy	Agroecology mentioned or not	FAO Elements of Agroecology									
			Diversity	Co-Creation and sharing of knowledge	Synergies	Efficiency	Recycling	Resilience	Human and Social Values	Culture and Food Traditions	Responsible Governance	Circular and Solidarity Economy
MARHP												
	PAP 2024		√	√	√	√		√	√		√	
	Water 2050	√	√	√	√	√	√	√	√		√	
	ACTA	√	√	√	√	√	√	√	√		√	
ME												
	PAN-LCD	√	√	√		√	√	√	√	√	√	
	MCPD		√	√	√	√	√		√	√	√	√
	SNTE	√	√	√	√	√	√	√	√	√	√	√
	(SNBC&RCC)		√	√	√	√	√	√	√		√	√
	SDDOT	√	√	√	√	√	√	√	√	√	√	√
	SPANB	√	√	√	√	√		√	√	√	√	
	SNGC-GSD			√	√	√	√	√			√	√
Joint MARHP–ME												
	PNS		√	√	√	√	√	√	√		√	

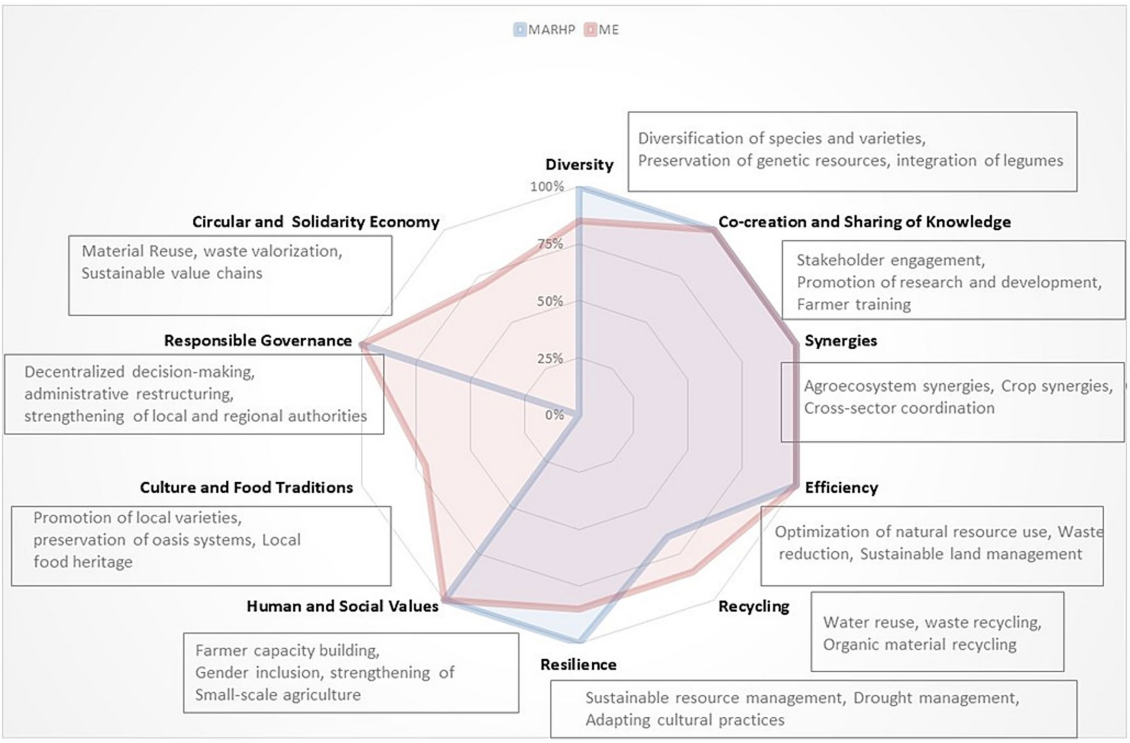

FIGURE 1
Percentage of strategies addressing FAO agroecology elements in MARHP and ME strategies and main actions implemented (in rectangles). The joint MARHP-ME strategy (PNS) was not considered in this analysis.

Water stress emerged as one of the primary constraints that climate change imposes on farming systems and natural resources (MARHP/ME, 2020, PNS; MARHP, Water 2050, 2022; ME, 2023a, SNGC-GSD). In response, the concept of "resilient irrigation," as proposed in the Water 2050 strategy (MARHP, 2022), was introduced. This approach is built around three main principles: improving water-use efficiency, adapting agricultural practices (e.g., crop selection and soil management) to optimize resource use, and shifting efforts from yield maximization toward a balance between profitability and water resource conservation. A similar approach was suggested in the PNS, which also advocated for the promotion of traditional know-how in water and soil management and conservation techniques (MARHP/ME, 2020).

Recycling and efficiency were also frequently highlighted in strategies. These two elements are strongly linked as recycling of organic material is inherently associated with the increase of resource use efficiency. Waste recycling and valorization, compost production and use in agriculture, and the use of treated wastewater for irrigation were the most recurrent practices (ME, 2016, MCPD; MARHP, 2022, Water 2050, ME, 2022a SNBC and RCC; ME, 2023a, SNGC-GSD). Among the objectives of the SNBC and RCC (ME, 2022a) is to increase the rate of organic (compost) and/or energy recovery to 45% by 2035, compared to 2020.

Diversity of species and varieties in production systems is one of the pillars of agroecology. The SPANB outlined a set of actions to protect and preserve the biodiversity in natural habitats and agroecosystems (ME, 2017). These include the monitoring of the conservation status of the wild flora, cultivated crops, rare and endangered species. In addition, and in order to maintain and enhance biodiversity in agroecosystems, a program aiming at promoting the sustainable farming practices was developed; it is based on the use of agroecological technical packages and sustainable land management techniques.

Diversity of species creates a synergy that provides benefits to crops, soils and the whole ecosystem. Legumes are one example of crops that, when integrated into crop systems contribute to increase diversity and to create synergies with the other crops through their nitrogen fixation action. Integration of food and fodder legumes in cereal systems dominated by monoculture was indeed highlighted in most strategies as an important pillar to improve soil fertility, increase cereal yields and diversify farmers income (MARHP/DGACTA, 2017, ACTA; ME, 2020, PAN-LCD; MARHP, 2022, Water 2050; ME, 2022a, SNBC and RCC). For example, the SNBC and RCC (ME, 2022a) strategy recommends increasing the share of food and fodder legumes in crop rotations on cereal-producing lands—from about 68,000 hectares in 2020 (INS (Institut National des Statistiques), 2025) to approximately 180,000 hectares by 2036. Synergies between actors were largely promoted across the different strategies through the establishment of partnerships and collaborations between sectors and institutions in water and drought management (MARHP, 2022, Water 2050; MARHP/ME, 2020, PNS) and in support of sustainability and resource efficiency, and climate resilience (ME, 2023a, 2023b, SNGC-GSD; SNTE).

Introduction of trees into farms, known as agroforestry, was also evoked as an agroecological practice to enhance the whole biological diversity, help combat wind erosion, and stabilize soil and water conservation structures (MARHP/DGACTA, 2017, ACTA; ME, 2020, PAN-LCD). In the case of oasis systems, conservation actions were planned to preserve the diversity of date palm cultivars, local fruit trees and traditional oasis system (ME, 2015). Precisely, the SPANB proposed to maintain the proportion of common date palm varieties (28%) relative to the total date palm trees (ME, 2017). Among these, the *Deglet*

Nour cultivar has long been the predominant variety in Tunisia, largely because of sustained state support and promotion (Kadri et al., 2022).

The SNTE emphasized the decline of biodiversity due to the gradual disappearance of landrace varieties from agricultural systems. In efforts to preserve this heritage, the National Gene Bank (NGB), an institution under the umbrella of the ME, is ensuring the regular collection of genetic resources and the free distribution of seeds, such as "*Mahmoudi*" durum wheat landrace and other resilient indigenous varieties over time, to farmers. At the legislative level, the strategy proposed to revise Law No. 99–42 on seeds and seedlings which confines the commercialization to improved varieties registered in the national catalog, thereby hindering the expansion of indigenous varieties in Tunisian agriculture and contributing to the loss of local biodiversity (ME, 2023b).

Diversity is not only related to production systems but also extends to consumed products in order to achieve a balanced and healthy diet. References to the diversity of consumed products were, however, limited in the strategies. It was only the MCPD action plan which encouraged the development and consumption of labeled products, such as fair trade and organic foods (ME, 2016). Actions supporting this objective included, for example, the integration of sustainability criteria into procurement processes launched by schools, canteens, and hospitals, as well as the creation of a new "Fair Trade" label that would be recognized internationally.

Mentions of culture and food traditions were also limited, and when present, were mostly found in strategies led by the ME. The SNTE, for instance, highlighted the place of the indigenous varieties in the national food heritage and encouraged the development and enhancement of their agricultural, medicinal, cultural, and social potential, in partnership with various local, regional, and national stakeholders (ME, 2023b). The oasis food and cultural heritage were, however, explicitly recognized, with actions aimed at preserving traditional palm-based knowledge, seed systems, palm by-products and food processing skills (ME, 2015, SDDOT). The promotion of sustainable tourism in oases was also emphasized in this strategy as a means of preserving local food cultures and traditions. As for SPANB, it focused on the valorization, preservation and use of local and traditional know-how for the conservation of biodiversity (ME, 2017).

Circular and solidarity economy was mentioned in the MCPD, SNBC&RCC, SNGC-GSD and SNTE (ME, 2016, 2022, 2023a, 2023b) from an angle of promoting a new economic paradigm based on notions of green, blue and circular economy. The use of this notion was described as aiming to foster sustainable consumption and production patterns, eliminate pollution hotspots, and restore contaminated sites. It also organizes the value chains around the approaches of reuse, recycling, and repair (ME, 2016, MCPD; ME, 2023a, SNGC-GSD). In the SDDOT, the social solidarity and circular economy models were promoted through seed sharing and women-led seed houses (ME, 2015).

4 Discussion: barriers to the agroecological transition

This section seeks to identify the constraints that are hindering the widespread adoption of agroecology in Tunisia based on the analysis of the strategies, insights from workshops as well as literature documents. Barriers may be inherent to the strategic visions themselves or have deeper structural and systemic roots that reflect past and present institutional and policy failures.

4.1 Compartmentalized and disconnected visions in agricultural and environmental strategies

According to the above analysis, agroecology is undeniably present in agricultural and environmental strategies through its multiple elements, reflecting a formal and policy-level commitment of the public authorities to shift from conventional and development-based paradigms to more sustainable, inclusive and resilient food production systems.

However, and despite the identification of convergent objectives regarding the necessity of improving governance and implementing practices that are environmentally sound and socially inclusive, the vision of the ME seems more holistic and transversal and gives more consideration to the systemic and integrated approach of agroecology (Figure 1). In contrast, we can note a segmentation of the agricultural policies with the development of "technical" action plans per sector such as the water (MARHP, 2022, Water 2050) or agricultural land development (MARHP/DGACTA, 2017, ACTA). Moreover, the absence of references to circular economy and culinary traditions in agricultural plannings (Figure 1) along with the focus on food production is evidence of a vision that is clearly still compartmentalized and incomplete where environmental, cultural and economic considerations are not prioritized to the same degree as agronomic imperatives. This "technocratic" orientation of agricultural policies has also been reported by Ben Bechr (2016), who called for a more horizontal approach that encompasses ecological performance, economic efficiency and social equity.

At the same time, the cross-cutting nature of strategies designed by the ME might also represent a possible weakness and barrier to their implementation. This is because they often suggest measures that are under the responsibility of other ministries, particularly the Ministry of Agriculture, and on which the Ministry of Environment has limited authority. For example, water management, pesticide regulation or seed distribution, stated in the SNTE strategy (ME, 2023b), lay within the MARHP's portfolio. The environmentally ambitious action plans developed in such strategies will depend on the willingness of the implementing ministry.

4.2 Institutional weaknesses and farmer exclusion in the agroecological agenda

The efforts put by the ministries to integrate agroecology and its principles in almost all the recent strategies were not accompanied with equivalent on-field efforts to communicate and raise awareness about the process. There is therefore a gap in including complementary awareness-building around agroecology and its medium and long-term interest which remains lacking within the farming community. Even if some pillars of agroecology are widely known and popularized within the strategies, such as the rotations in cereal production systems, other essential information remains fragmented with only a minority of actors having an exhaustive knowledge of the different components of agroecology. To a certain extent, this lack of knowledge also extends to agricultural advisers and even to the support services of MARHP. As a result, there is still relatively little training dedicated to farmers to encourage them to engage in an

agroecological transition (Souissi et al., 2024; Gharbi et al., 2025). It is clear that the gradual dismantling of the public agricultural extension and advisory system, that took place in the early 1990s as part of structural adjustment policies, weakened the capacities of extension services and limited their role as an interface between research and the producers thereby restricting the implementation of new techniques and production systems (Elloumi, 2008; Elloumi, 2018). Consistent with these observations, the outcomes of the workshop, held in May 2024, clearly identified lack of knowledge as one of the main barriers to the adoption of agroecological practices at the farm level by farmers (Caulfield et al., 2025).

Institutional gaps between strategies and their operationalization were largely reported by farmers who highlighted the absence of long-term strategies and actionable regulations to put into practice agroecological methods (Figure 2). They emphasized that even when such regulations exist, the State does not ensure their proper application. What is certain is that some scattered activities aiming for the disseminating of practices at individual level, such as the no-till sowing or crop rotation, do exist. However, agroecology is not a set of individual practices but rather a holistic philosophy centered on the harmony with nature and on social justice, with farmers being at the center of the transformation as partners in the design, implementation, and evaluation of agricultural policies and programs. Despite that fact, farmers declared feeling unheard, marginalized and excluded from decision-making processes (Figure 2). As expressed by a farmer during the workshop held in April 2024: "Decisions are taken without considering our opinions, while we are the only ones who truly know the reality on the ground. The State acts as if farming is not a real profession and does not consider that we have the right to earn a living like in other sectors".

Other gaps also lie in the absence of financial and technical support provided by the State to support a widespread adoption of agroecological practices. Subsidies are in fact still applied for conventional inputs, material and equipment such as synthetic fertilizers, irrigation equipment, and chemical pesticides and there is no effort put in place to make alternative agroecological inputs or equipment available and more accessible to farmers. One concrete example of this situation is the farmers' limited access to no-till seeders. A survey conducted by the "Conservation Agriculture in the Maghreb" project in 2016 showed that the unavailability of no-till drill was the main cause of farmers' return to conventional seeding (FERT, 2016). This constraint was also highlighted during the workshop held in May 2024, when farmers discussed the barriers to the adoption of no-till sowing. As one farmer explained "with sowing occurring within a short time window and the number of available no-till drills being limited, I was forced to return to conventional seeding".

Compared to Tunisia, Morocco has taken more concrete measures to encourage conservation agriculture. As part of its Green Generation Strategy, that aims to convert 1 million hectares of cereals to conservation agriculture by 2030 (Moussadek et al., 2024), the Moroccan government has actively worked on increasing the farmers access to direct seeders by offering subsidies for their purchase (up to 50% of the cost of direct seeders). For the 2024/2025 agricultural season, that aims to cover an area of 260,000 hectares, the program included the distribution of 200 no-till seeders to agricultural cooperatives along with efforts to provide support to farmers in adopting this technique (Ministry of Agriculture, Morocco, 2024).

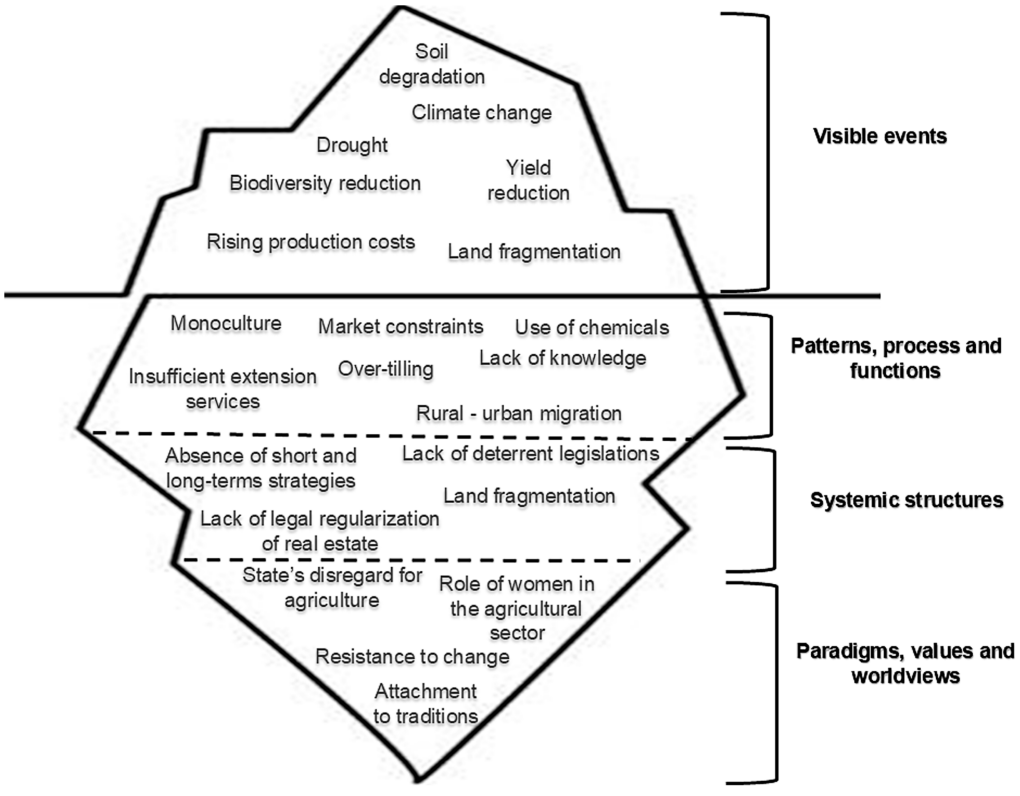

FIGURE 2
Iceberg model illustrating visible and underlying factors affecting the agricultural system.

4.3 Tensions between food security and sustainability

The evolution of Tunisian agricultural policies shows that it has historically prioritized food security, productivity, and market integration. In recent years, sustainability and climate adaptation have been progressively incorporated into policy frameworks, largely driven by the international agendas promoting sustainability and social inclusion. However, the extent to which these objectives can converge remains questionable. According to Carpentier (2025), the State struggles to achieve almost "contradictory" goals: satisfying the population's growing food demand while improving sustainability, preserving natural resources, and addressing social needs. These objectives do not carry the same weight in terms of concrete actions on the ground: policy decisions continue to be dominated by narrow interpretations of food security while sustainability often remains secondary and largely discursive (Schütze et al., 2025).

This prioritization is evident in the annual MARHP's performance projects (PAP) which outline the Ministry's key programs, priorities, and budget allocations. According to the PAP 2024, self-sufficiency in durum wheat, milk and red meat is the main priority of its first program "Crop Production, Food Safety and Agricultural Quality". This comes despite a World Bank (2014) report that criticized the current system of state intervention, that distorts the sector by prioritizing the production of staple goods such as cereals, beef, and milk; products in which Tunisia is not competitive although acknowledging its contribution to social stability.

This self-sufficiency policy has created several adverse effects:

- Artificial productivity gains, which are more reflective of state support than true agricultural performance.
- Distorted incentives, where farmers align their crop choices with state subsidies rather than agronomic or market logic. Policies encouraging legume cultivation were often more modest in comparison to those for cereals, and have, therefore, failed to promote their integration into cereal systems meaningfully. Legume-cultivated areas dropped by 10.7% from 2019 to 2023 (ONAGRI, 2024), due to a lack of sufficient support, coupled with unstable prices, inadequate collection and market fluctuations. Consistent with this, lack of stable markets for legumes was identified as one of the main constraints to the adoption of agroecological practices at the farm level during the two workshops held in April and May 2024 (Figure 2; Caulfield et al., 2025). While farmers were aware of the agronomic benefits of legumes in cereal systems, they emphasized the lack of stable markets for these products. As one farmer stated regarding market fluctuations during the May 2024 workshop "I cultivated fenugreek as a preceding crop for wheat, and I could sell it easily. Two years later, the market for this product was no longer available. However, I continue to grow fenugreek because of its remarkable effects on wheat yield".
- Environmental degradation, such as monoculture, tillage, overgrazing, and low organic amendment, led to low soil fertility and high erosion. In particular, the sequence of plowing and tillage operations traditionally practiced in cereal systems before sowing damages the soil structure and accelerates the microbial activity leading to organic matter reduction (Jendoubi et al., 2019). In Tunisia, most cultivated soils have low organic matter, often below 0.5% (Grissa, 2017). Consequently, agricultural land faces a significant risk of soil water erosion. A study conducted in 2023 showed that 6.43% of the surface of Tunisia is affected by a very high soil loss rate (>30 t ha $-$ 1 y $-$ 1) and 4.20% by high soil loss rates, ranging from 20 to 30 (t ha $-$ 1 y $-$ 1); the northwestern part of the country emerges as the most vulnerable region (Jendoubi et al., 2019).
- Despite the unsustainable use of water resources, with an exploitation rate of 119% for surface aquifers and 149.7% for deep aquifers in 2022 (MARHP, 2023), the MARHP strategy still encourages the development and expansion of irrigated agriculture with the specific target of increasing average yields of durum wheat, potatoes, and tomatoes to 4.6 t/ha, 26 t/ha, and 75 t/ha, respectively, by 2025 (PAP, 2024).

Taken together, these elements show that while the MARHP increasingly references sustainability and agroecology in its long-term strategies, its concrete actions on the ground remain anchored in a conventional, high-input model aimed at short-term productivity. Particularly as climate change predictions suggest a decline in rainfed agriculture productivity and a sharp reduction of the water recharge of the aquifers this contradiction poses significant challenges to the resilience and sustainability of Tunisian agriculture.

4.4 Land tenure and financial barriers

Land tenure and financial constraints are major factors limiting agroecological transition in Tunisia. Land fragmentation is characteristic of the rural agricultural landscape in Tunisia and is the result of inheritance laws that allows to divide land into progressively smaller plots across generations. Nearly 54% of farmers cultivate areas lower than 5 ha. Such small areas can limit diversification and rotation of crops as well as the implementation of soil and water conservation practices, such as contour plowing and earth bunds (MARHP/AVFA, 2016). Beyond the technical aspect, small plots, in general, do not generate substantial profits (Aslam and Fazal, 2025). This limits the ability of the farmers to invest in innovative practices and technologies and shapes their perception of change, which might be viewed more as a risk than as an opportunity. Faced with land fragmentation, farmers often turn to land rental to expand their areas. This weakens their long-term commitment to sustainable land management. Agricultural practices are therefore often driven by short-term economic returns rather than the preservation of soil health, environmental integrity, or the resilience of agroecosystems. During the workshop held in April, 2024, land fragmentation was one of the most frequently reported constraints, highlighting its impact on the adoption of sustainable agroecological practices. One tenant farmer admitted: "I cultivate the land intensively until its productivity is exhausted, then move to another plot". Such practices perpetuate a cycle of land degradation and unsustainable resource use.

Inheritance laws also led to highly limited women's access to land-ownership impairing the principle of gender equality. Although women represent 38% of the agricultural workforce (The African Development Bank, 2024), they currently own less than 5% of Tunisia's agricultural land (Jouili, 2023). Even if they could sustain their work on land owned by their male relatives, it is highly unlikely to obtain full ownership rights. In fact, formal land titles in Tunisia are lacking and lead to difficulties in accessing property. This in turn hinders land transactions and prevents access to credit, since banks typically require land as collateral; thereby leading to a major issue in land tenure dynamics.

Hence, despite Tunisia's rich agroecological heritage and decades of initiatives, adoption remains slow, mostly because of institutional, regulatory and policy shortcomings. One striking example is conservation agriculture: initiated in Tunisia in 1999, it has shown promising research results (Angar et al., 2014), yet adoption and upscaling have remained modest compared to other countries like Syria (Friedrich et al., 2012) and more recently Morocco. In 2022, the area managed under conservation agriculture systems in Tunisia was estimated at only about 16,000 ha (M'Hamed et al., 2022).

5 Conclusion and recommendations

In this paper, we proposed to assess the potential for an agroecological transition in Tunisia through an analysis of literature and recently released agricultural and environmental strategies and policies, complemented by insights from farmers gathered during workshops. The analysis of documents released by the MARHP and the ME indicates a growing effort to integrate agroecological principles into their respective strategic frameworks, irrespective of their thematic orientation. Nevertheless, an examination of the FAO's elements of agroecology reveals differences in the ways in which the two ministries approach and interpret agroecology.

The examination of the scale at which agroecology is addressed by the MARHP indicates that its application remains largely confined to the farm and agroecosystem levels, reflecting a relatively "conservative" vision. This partly explains the predominantly technical and narrow orientation of agricultural strategies, which miss the complexity and transdisciplinary nature of agroecology as a holistic approach.

Meanwhile, the strategies of the ME appear to have progressed toward the broader and more transformative dimension of food systems, as evidenced by their cross-cutting approaches, notably the SNTE. However, some of these actions might never materialize because they overlap with the prerogatives of MARHP. Implementing shared governance mechanisms and developing joint strategies, that would be more realistic, credible and applicable, could help to overcome this obstacle and ensure stronger application on the ground. Additionally, such collaboration would allow both ministries to pool resources and optimize budgets.

Governance is not the only barrier to the implementation of the agroecological transition. Deeper and more structural policy-related constraints are likely the main causes of this blockage. Tunisia struggles to balance its development priorities and faces several trade-offs that often limit the adoption and scaling of agroecology. Tunisia has long placed self-sufficiency at the center of its food security policy. To achieve this goal, it has implemented a range of productivity-oriented measures, including monoculture of durum wheat- instead of the implementation of a rotation policy- or the extension of irrigated areas despite limited and non-renewable water resources. These actions may run counter efforts of soil rehabilitation, crop diversification or the rational management of resources. The focus on short-term productivity and self-sufficiency therefore creates trade-offs that can limit the adoption and scaling of agroecological practices.

It is clear that the transition to agroecology has a cost in the short term, particularly in contexts characterized by water scarcity and land degradation. Despite the ongoing evolution of scientific evidence showing long-term benefits of agroecological practices on yields and land productivity (Pretty et al., 2006; Altieri et al., 2012; M'Hamed et al., 2022; Woodcock et al., 2025), some suggest that a decline can be noticed during the early stages of transition during which ecosystems are stabilizing their ecological balance (Rusinamhodzi et al., 2011; Parmentier, 2014; Devi et al., 2025). The duration of the transition is highly context-specific and depends intimately on the degree of soil degradation, previous land management practices, and level of dependence on chemical inputs (Parmentier, 2014). Financial and technical support are therefore fundamental to assist farmers during the transition process with, for example, the provision of adequate subsidies, technical support and capacity-building programs. As these need to be tailored to local conditions, the availability of highly competent and well-trained extension services is necessary to guide farmers through the early stages of adoption and to ensure the successful establishment of agroecological systems.

The support also involves addressing more structural issues, such as those related to land tenure, property rights and access to credit. Even the creation of socially fair environments and the implementation of inclusive and participatory approaches depend on adequate financial resources. In the current financial and economic context, Tunisia's readiness to support a full agroecological transition remains uncertain. It will largely depend on the country's capacity to implement a multitude of complementary actions including better access to financial resources, policies that encourage investment in agroecology, and the establishment of more efficient governance mechanisms. Such approaches should prioritize support for farmers and their needs, strengthen institutional capacities, provide training and incentives for the adoption of sustainable practices, and address issues such as market access. These conclusions align with Gharbi et al. (2025) recommendations aiming at accelerating the agroecological transition in Tunisia, such as updating of land property titles, improving access to credit and strengthening of farmers' technical capacities.

Insights gathered from the farmer workshops highlighted a high level of frustration among farmers, who called for acknowledgement of their role within the social dynamics of the country and more generally for a stronger recognition of rural areas, which have been historically marginalized throughout Tunisia's colonial and post-independence development processes (Elloumi, 2018). These insights revealed a paradox: while governance, social and human dimensions were acknowledged in all the national strategies analyzed, farmers' perception is poles apart, indicating an inefficient implementation of these orientations on the ground. Public institutions should adopt more inclusive and participatory governance mechanisms. This approach should also be made visible for all actors, and farmers particularly (Gharbi et al., 2026). For that, probably aware of these gaps, several agroecology projects were designed to support multi-stakeholder participatory platforms and engage farmers in identifying the challenges and co-creation of solutions tailored to the local contexts such as the SEEDS (2024) and NATAE (2023) projects. These participatory activities are creating dynamics around agroecology and, somehow, preparing the ground for potential, more structured State intervention in the transition process.

Based on the barriers and paradoxes identified in this study, several recommendations can be proposed to help translate these findings into policy action. First, a permanent joint inter-ministerial working group between the MARHP and the ME should be established to harmonize strategy objectives and resolve the regulatory contradictions documented in this study. Second, the current subsidy system should be revised in order to redirect a portion of the conventional input subsidies budget toward agroecological inputs and financial support for farmers during the

transition period. Third, public agricultural extension services must be substantially strengthened, and specifically mandated to support the agroecological transition, with farmer-led participatory platforms being a central tool in this process. Finally, a national land title regularization program should be prioritized, and alternative financial guarantee mechanisms should be developed for smallholder farmers. Also measures to improve women's access to land and finance should be implemented, including appropriate legal reforms.

While these measures are not expected to eliminate the structural tensions documented in this study, they can help reduce the gap between policy discourse and ground realities, identified in this paper, as a central challenge of Tunisia's agroecological transition.

Author contributions

IZ: Conceptualization, Data curation, Methodology, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. SJ: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. RJ: Conceptualization, Writing – review & editing. HB: Writing – review & editing. YT: Validation, Writing – review & editing. SA: Writing – review & editing. MR: Supervision, Validation, Writing – review & editing. MBM: Supervision, Validation, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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