Javier Becerril García ·
Paulina Martinez Isidro · Praveen Jha ·
Elisabeth Tuider · Andreas Thiel *Editors*

# Sustainable Agroecology

## Actors, Practices, Experiences and Perceptions

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# Chapter 1
# Mayan Agrodiversity Resilience: An Analysis of Structural Changes in the Rural Economy and Public Policy




**Javier Becerril García and Francisco Iván Hernández Cuevas**

**Abstract** The Mexican economy has undergone significant changes in recent decades, moving from a closed model to a completely open one. As a result, economic policy has undergone substantial changes, affecting the agricultural sector. Public policy programs have played a major role in this transformation. The Yucatecan economy, specifically the Milpa sector (local agricultural system) and Solar (home garden agriculture production), has also experienced these changes. The Mayan culture has proven to be highly resilient to historical and economic changes and is now facing two significant challenges: globalization and climate change. This study employs a household decision-making framework and *Poisson* econometric model and shows significant results in a quantitative analysis spanning 13 years, with cross-sectional designs detailing the evolution of the Maya and Solar farmers' households, from 2248 in 96 villages. The findings show that the loss of agrodiversity in Milpa and Solar systems, over time, also contributes to the increase in temperature, changes in season, and amount of rainfall. The agrodiversity still exists in old Milpa farmers >48.5 years, family labour provision; an important component of economic theory is the economy of scale that beekeeping provides to Milpa and Solar activities. Classical economic theory suggests that market failure, characterized by high transaction costs and limited access to markets for labour and supplies, plays a role in preserving local agrodiversity. In this context, the distance in kilometers from villages to the main market center contributes conservation of agrodiversity, intact niches of local crops, and Mayan cosmovision is in situ, in an agroecological (According to Gliessman (2015), agroecology involves "the application of ecological concepts and principles to the design and management of sustainable agricultural ecosystems." The Food and Agriculture Organization of the United Nations (FAO) describes agroecology as "a holistic and integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of sustainable agriculture and food systems" (FAO, 2018). Key

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components of agroecology include biodiversity conservation, soil health, minimizing external inputs, and fostering equitable relationships in food systems (Altieri, 1995).) system de facto.

**Keywords** Agroecology · Agrodiversity · Milpa · Maya

## 1.1 Introduction

The Maya Milpa (*Ich kool* in Mayan) is an agroecological system de facto associated with the planting of poly-crops (based on Maize, Beans, and Squash), the use of ancestral traditional knowledge, and economic activity that affects the income of rural households and food sovereignty (Avalos-Rangel et al., 2021; Fonteyne et al., 2023; Rodríguez-Robayo et al., 2020). However, it was not until 1942 that the Milpa was defined as an integral production system, with an expansion in the academic sphere in the 1960s, 1970s, and 1990s, with greater participation by civil society organizations and non-governmental organizations (Jiménez-Osornio et al., 2022).

Despite their importance in terms of sustainable livelihoods and their international relevance as FAO's Globally Important Agricultural Heritage Systems (GIAHS) in November 2022, few studies and statistics monitor the current state of the Maya Milpa and agrodiversity, its evolution in the planted area, the sociodemographic characteristics of practitioners, and the biophysical conditions.

The Milpa is an integral part of the livelihood of many Maya-Yucatecan small-scale farmers, involving the rational appropriation of nature mainly to meet family, community, and regional needs (Martín Castillo, 2016). Therefore, the role of Mexican and Yucatecan small-scale farmers centers on maintaining the diversity of local crop varieties, particularly maize and beans, along with poultry, livestock, beekeeping (Melipona or native bees), horticulture, forestry (which encompasses a wide range of agrobiodiversity), and handicrafts. They also work to preserve traditional knowledge about cultivating their local varieties and the practices of saving and sharing seeds among themselves from one cycle to the next (Bellon et al., 2018; Jago & Borrell, 2024).

However, widespread loss of local crop diversity has been documented over the past century and continues today. The main drivers of loss are agronomic, demographic, land use, environmental, and market changes, along with development processes and deficiencies in seed systems (Khoury et al., 2022).

This chapter answers the following research questions in depth: Who are the actors involved in agroecological transformations? (Peasants? Families? Communities? The State/Government?) What factors contribute to maintaining agroecology in situ? What factors influence the loss of sustainable agroecology and its agricultural diversity?

## 1.2 Historical Structural Changes in Mexico

The Mexican economy has undergone significant historical and structural changes over time, influenced by both internal and external factors as well as the policies adopted by various governments. According to Quezada et al. (2014) and Velásquez García et al. (2017), in modern history, the Colonial Economy (1521–1821) is notable. During this period, the economy focused on resource extraction, particularly minerals like gold and silver, for export to Spain, establishing an extractive economic base. Systems such as the *encomienda* and the *repartimiento* were implemented, which exploited the indigenous population. In the agricultural and livestock sector, Spain controlled foreign trade, severely limiting local economic development. Before 1821, the Milpa system was central to Mesoamerican agriculture, essential for food security and the indigenous cosmovision. Although European crops were introduced with the arrival of the Spanish, the Milpa system remained vital for indigenous communities. However, colonial policies favoured large estates while marginalizing small producers.

The next period, Independence (1821–1910), experienced a weakened economy caused by various conflicts, including political instability and wars like the conflict with the United States (1846–1848) and the French Intervention (1862–1867). During the *Porfiriato* (1876–1910), foreign investment, railway development, and growth in sectors such as mining and oil were encouraged. However, these benefits primarily accrued to the elites, leaving much of the population marginalized. Large estates continued to expand, displacing indigenous and peasant communities. Although corn remained the main crop, its production lagged due to insufficient government support for small farmers.

The third period, the Mexican Revolution and Post-Revolution (1910–1940), focused on agrarian redistribution. The Revolution led to agrarian reforms, including expropriating land to create *ejidos* (communal properties). The 1917 Constitution established the *ejido* as a form of communal property to redistribute land to peasants, aimed to empower small producers. However, implementation was slow. During this time, corn was promoted as a key crop to ensure food sovereignty. In 1926, the National Ejidal Credit Bank was founded to provide credit to *ejidatarios*. Additionally, the 1917 Constitution established labour rights and control over natural resources, including oil. In the 1930s, Lázaro Cárdenas' administration nationalized the oil industry (PEMEX in 1938) and reinforced the state's role as the economy's regulator.

The fourth period, known as the Mexican Miracle and the Green Revolution (1940–1970), was characterized by a model of import substitution industrialization (ISI). This era featured protective policies for local industries through tariffs and subsidies. GDP growth exceeded 6%, and inflation remained low, leading to a boom in urban areas at the expense of rural regions. The Green Revolution introduced improved seeds, chemical fertilizers, and irrigation systems, mainly targeting crops like maize. However, policies predominantly favoured large producers, further marginalized small subsistence farmers reliant on the Milpa system. In 1961,

CONASUPO (*Compañía Nacional de Subsistencias Populares*) was established to stabilize and make prices for corn and other basic products more accessible.

The fifth period, covering 1970–1994, was marked by economic crises and structural adjustments, including rising foreign debt and falling oil prices—Mexico's heavily oil-dependent economy leading to a severe crisis. In 1980, Mexico adopted a "neoliberal" model that involved privatizing state enterprises, liberalizing trade, and deregulating. Mexico joined the General Agreement on Tariffs and Trade (GATT) in 1986, opening its economy to international trade. The signing of the North American Free Trade Agreement (NAFTA) in 1994 further integrated Mexico's economy with those of the United States and Canada. The 1982 debt crisis led to a reduction in agricultural subsidies and the liberalization of agriculture. Mexico's participation in GATT and NAFTA increased competition from foreign agricultural products, especially Maize, adversely impacting small producers and the Milpa system due to reduced support and the influx of subsidized US maize.

The sixth period, known as globalization and transformation (1994–2020), saw the Mexican economy focus on exporting manufactured goods, particularly automotive and electronic products. During this time, remittances sent by Mexican migrants became significant, positively impacting the agricultural sector, especially small producers. However, Mexico also became a net importer of maize, which compromised its food sovereignty.

In response to neoliberal policies, organizations like the Zapatista Army of National Liberation (EZLN) protested and demanded greater support for the agricultural sector. Considering the effects of transgenic maize and imports, various policies and movements emerged to protect native maize varieties and promote traditional agricultural practices, such as Milpa. In 1994, public policy programs were instituted, with the Rural Support Program (PROCAMPO) being a prime example aimed at assisting farmers, although its benefits were limited for small subsistence growers.

### *1.2.1 Contemporary Economy (2020 Onwards)*

In 2020, NAFTA was replaced by the USMCA, further strengthening trade relations with North America. The current government's program aims to revive traditional practices like milpa while integrating reforestation efforts and economic support for small subsistence producers. Additionally, in 2020, the federal government announced the gradual elimination of transgenic corn and the use of glyphosate to protect the biodiversity of native Maize. This decision has sparked controversies with trading partners, including the United States and Canada. The new policy encourages self-sufficiency in basic grains, especially corn, through guaranteed prices and direct support for small producers.

## 1.3 Mexican Countryside and Public Policy

The Mexican countryside has undergone important structural changes in social, productive, and environmental policies, which have had multiple effects on the dynamics of the rural and agricultural population. In summary, from 1975 to 2000, the country transitioned away from a model of state corporatism, characterized by the development of a system of incentives focused on the agricultural sector and the liberalization of the commercial regime (modification of Article 27 of the Constitution). The aim was to improve the functioning of rural markets, encourage investment, and enforce the rule of law in the countryside (Gordillo, 2004).

The period from 2000 to 2018 was characterized by a democratic regime with a liberal political stance and limited sectoral policies. During this period, there was a disconnect between government policies and the needs and characteristics of the Mexican countryside.

In the case of Yucatán, the changes in the rural environment were marked by the economic activities carried out, especially in agriculture, centered on maize cultivation, and by a significant boom in the henequen industry, which propelled the fiber industry to account for 50% of the state's total production until 1983, when it dropped to less than 6%. The 1970s in Yucatán was characterized by increased government spending in the form of subsidies and investment in infrastructure. Finally, in the 1980s, there was an economic shift towards trade, services, and other agricultural industries (including poultry, pork, livestock, among others) (Baños Ramírez, 2000).

## 1.4 Milpa and Solar: A Sustainable Agroecological System De-Facto

According to Terán and Rasmussen (1994), Maya Milpa is rooted in ancestral knowledge and indigenous recognition, which form the philosophical and spiritual foundations and premises of the system that have preserved its essence over the years.

The Maya Milpa is a traditional agroforestry system, formed by a polyculture that creates a dynamic living space of genetic resources. It is characterized by its knowledge and cultural adaptations, as well as its diverse strategy based on sowing a wide variety of plants (maize, beans, squash, and others) and engaging in multiple productive activities (diverse economy).

The Maya Milpa is practiced in plots using *slash*-and-*burn* cultivation. Typically, farmers alternate between years of planting and years of fallow to restore soil fertility, control weeds, and manage harmful pests.

Productive diversity is fundamental to the Milpa family's economy, encompassing vegetable plots, orchards, animal husbandry, and handicraft activities, among others. Activities that arise from community forest management include firewood

collection, lime and charcoal production, timber for houses, medicinal plants, hunting, and beekeeping. This diversity of activities makes the milpa a complex system and a benchmark in the sustainable use of biodiversity.

The Maya Milpa is an integral part of the Maya cultural heritage, with its language and its cosmovision. In its traditions are latent beliefs about the existence of supernatural and divine owners of nature, which are reflected in agroecological practice and rituals. These customs have continued thanks to the core values of solidarity, reciprocity, and community support among indigenous communities.

Maize, which is the most important plant in the Milpa because it provides the main food, has over 60 breeds—of which 59 are native (Bellon & Brush, 1994)—adapted to different altitudes, climates, and soils. Within these breeds, there are also variants. Maize in the Sierra of Puebla does not grow in Yucatan, and vice versa. This means that although milpas are all over Mesoamerica, each milpa is different.

Besides the core species planted together in the same hole, many other species have been sown directly in the milpa through intercropping, such as other beans and cucurbita species. Additionally, some crops are sown in the so-called *Pach Pakal*, where vegetables and roots are cultivated, taking advantage of the best soils of the milpa. Another part of the milpa system includes the polyculture of the plot.

In the Mayan language, the forest is called *kaax*, and in the Spanish spoken in the region, it is referred to as "monte." In this text, we consistently use "the land" and "vegetation" as synonyms for "monte," "forest," and "vegetation and plant life." Land is almost a non-existent concept in the Maya Peninsula because fertility is in the vegetation, and we can only find soil and land in the southern part of the Yucatán.

The milpa provides high-quality nutrition because the three species that comprise the core of the polyculture—corn, beans, and squash—contain all the nutrients the human body requires: carbohydrates, proteins, fats, vitamins, and minerals.

## 1.5 Climate Change, Yucatan Evidence, and Experiences

Yucatán is located in a tropical zone characterized by warm climates (*Aw* and *Ax*), with a dry climate found in the northwest corner (*Bw*). Frost is absent, and the region receives an average annual rainfall of between 1000 and 1200 mm, accompanied by a high relative humidity. Rainfall follows a northwest-southeast gradient, and this distribution gradient is also reflected in the forests. The vegetation primarily consists of xerophytic plants in the northwest corner, where the climate is dry. The average annual temperature is 26 °C. The prevailing weather conditions and temperature create an environment conducive to agricultural pests.

There are two main seasons: the rainy season, from June to November, and the dry season, from December to May. There are two distinct drought periods. The first, known as the pre-summer drought, is characterized by its prolonged and gradual onset. The second, the *intra-estival* drought, known as a heatwave, is often shorter, but extremely intense. This intense drought can have catastrophic effects on

agriculture, particularly on crops like maize, leading to significant losses. This intra-estival drought occurs between July and August.

In the southeast region of Mexico, intensive monoculture farming of crops such as soybean, avocado, oil palm, and sugarcane has led to significant deforestation in regions like Chiapas, Campeche, Tabasco, Quintana Roo, and Yucatán (MONGABAY, 2023). Forested areas are being transformed into large plantations, exacerbating environmental degradation as land is cleared for large-scale food production.

Besides, climate variability is leading to adverse impacts on agricultural production across all scales. Variations in temperature, water scarcity, shifts in pest population dynamics, among other factors, are influencing production outcomes (Nicholls et al., 2015). Moreover, increasingly intense natural disasters are resulting in significant losses, such as tropical cyclones in Yucatán, given its location within the Atlantic hurricane belt. Since 1985, there has been a noticeable increase in the frequency of extreme events in the Yucatán Peninsula, which is likely attributed to climate change, particularly the rise in temperature in the region. In 2020, several tropical cyclones adversely affected agricultural production in the peninsula, resulting in substantial crop losses across various municipalities in the state (Gobierno del Estado de Yucatán, 2020).

## 1.6 Household Decision-Making Framework

The agricultural household is one of the economic units where multiple decisions are made regarding the use of physical, natural, and human resources. Examples of these decisions include the division of labour among household members, the allocation of responsibilities, investments in machinery, production methods, and crop protection practices. These decisions are influenced by both "on-farm" factors, which pertain to the production systems the household operates, and "off-farm" factors (French, 1995).

In the agricultural household model, production and consumption decisions are interconnected (recursive household), as the household functions simultaneously as both a producer and a consumer (Singh et al., 1986). As a producer, the household allocates labour and other inputs for agricultural production. As a consumer, it uses income from agricultural profits and wage labour to purchase goods and services. This dual role means that the choices made in production and consumption are inherently linked within the household's economic unit (López Santiago et al., 2013; Taylor & Adelman, 1996).

The interaction of all these factors (refer to Fig. 1.1) can lead to multiple scenarios and objectives, including maximizing the utility of productive systems, maximizing household welfare, or conserving available resources. This study specifically focuses on the latter aspect, identifying the factors that influence households' decisions to increase agrobiodiversity within agroecological systems typical of rural Yucatecan environments: milpa and home garden.

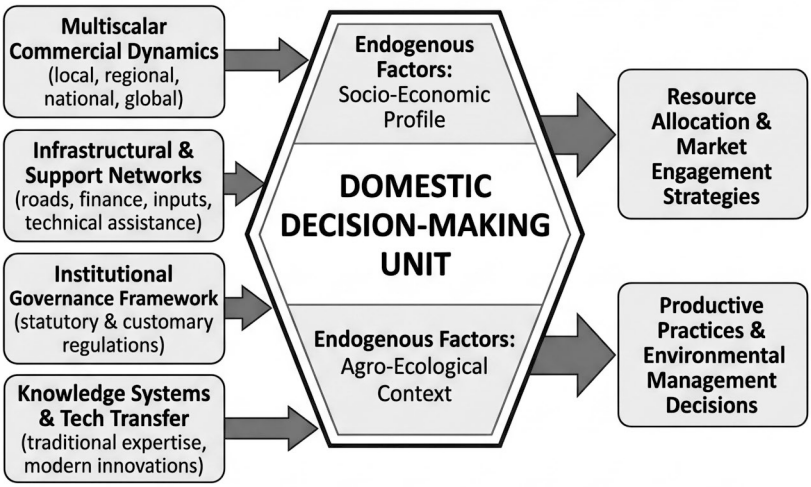



**Fig. 1.1** Interaction of all factors on household decision. Source: Author's own elaboration based on the theoretical framework of French (1995)

## 1.7 Method

A quantitative study, spanning 13 years and employing cross-sectional designs, details the evolution of the Mayan Milpa territory in the state of Yucatán. It is based on surveys conducted with 2248 Milpa farming household surveys across 96 villages in 42 municipalities (See Appendix for more details) (Fig. 1.2).

### *1.7.1 Econometric Model*

#### 1.7.1.1 Dependent Variable for Poisson Model

Given the interest in studying agrodiversity on farms (in situ) within an agroecological system, de facto at the household level, the number of farmer varieties or local crops serves as a straightforward measure of richness. This measure is defined as the count of the different crops that a household plants in the Milpa and Solar systems (van Dusen & Taylor, 2005). The count of these crops is the dependent variable in the regression model.

The structure of the dependent variable is illustrated in Graph 1.1 as a histogram. This graphical representation indicates that the dependent variable follows a typical *Poisson* distribution. The variable has many zeroes and incorporating a mixture process may improve the model.

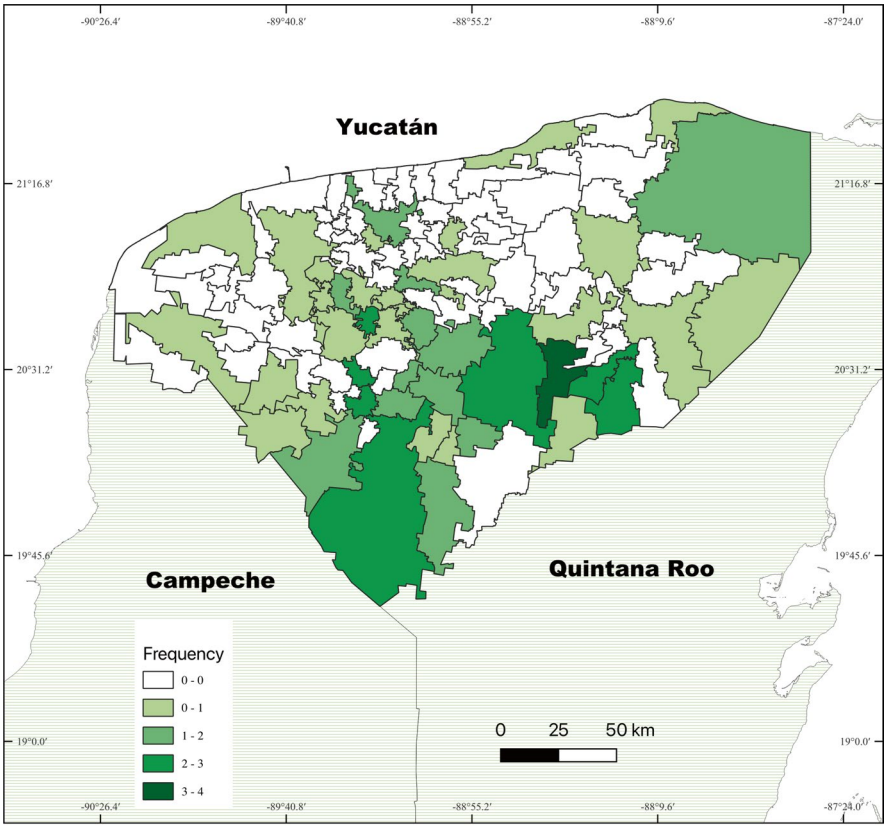
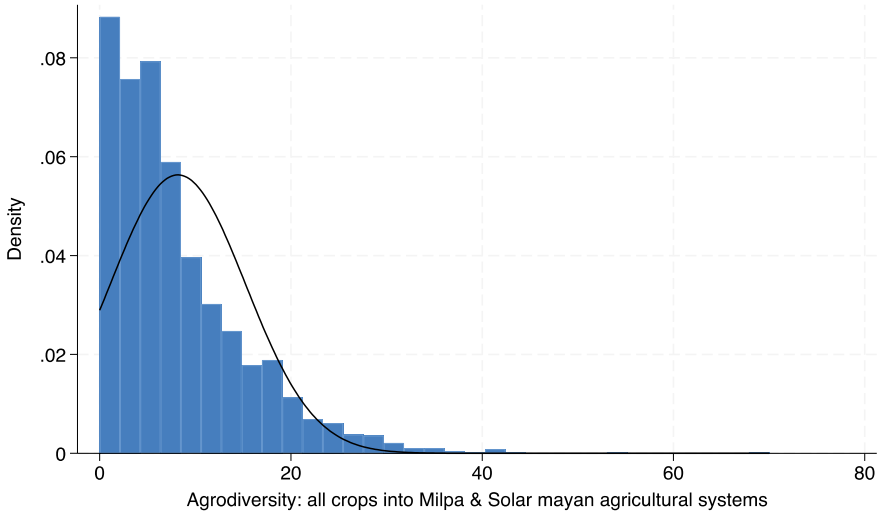



**Fig. 1.2** Study area. Source: Author's elaboration

*Poisson* regression is a commonly used technique for modelling count data. It is a type of generalized linear model that assumes the response follows a *Poisson* distribution conditional on a weighted sum of predictors. However, one potential drawback of *Poisson* regression is that it may not accurately capture the variability in the counts. This is because a *Poisson* distribution is parameterized by $\lambda$, which represents both its mean and its variance. Such a scenario is rarely seen in microeconomic and empirical data, which is the case for the variable analyzed in this study.

Count distributions usually have a variance that is not equal to the mean, also known as underdispersion or overdispersion, depending on whether the variance is smaller or larger than the mean. Therefore, a poorly fitting model will result from running *Poisson* regression on count data with such characteristics.

One way to address this issue is through negative binomial regression. Like the *Poisson* distribution, the negative binomial distribution describes the probabilities of occurrence for integers greater than or equal to 0. However, unlike the *Poisson* distribution, the mean and variance are not equal. The variance of a negative




**Graph 1.1** Histogram for dependent variable. Source: Author's elaboration

binomial distribution depends on its mean and an additional parameter, $k$, known as the dispersion parameter. If we consider our count as a random variable $Y$ following a negative binomial distribution, the variance of $Y$ is expressed as:

$$var(Y) = \mu + \frac{\mu^2}{k}$$

The negative binomial model is a generalization of the *Poisson* model (Greene, 2020). It introduces an unobserved individual effect into the conditional mean:

$$\ln \mu_i = x_i^{'}\beta + \varepsilon_i = \ln \lambda_i + \ln u_i$$

where the disturbance $\varepsilon_i$ reflects either specification error. Then, the distribution of $y_i$ conditioned on $x_i$ and $u_i$ remains *Poisson* with conditional mean and variance $\mu_i$:

$$f\left(y_i \mid, x_i \mid, u_i\right) = \frac{e^{-(\lambda_i u_i)}\left(\lambda_i u_i\right)^{y_i}}{y_i !}$$

The negative binomial model can be estimated by maximum likelihood.

## 1.8 Data and Descriptive Analysis for *Poisson* Model

The data used in this study were obtained from different surveys involving 2248 small-scale farming households, randomly selected from 42 municipalities and 96 villages in rural areas in Yucatán, Mexico. The information about these households

**Table 1.1** Number of farmer households randomly selected by year

| Year | Freq. | Per cent | Cum. |
|---|---|---|---|
| 2009 | 247 | 10.99 | 10.99 |
| 2010 | 371 | 16.50 | 27.49 |
| 2011 | 392 | 17.44 | 44.93 |
| 2013 | 420 | 18.68 | 63.61 |
| 2017 | 313 | 13.92 | 77.54 |
| 2018 | 123 | 5.47 | 83.01 |
| 2023 | 382 | 16.99 | 100.00 |
| Total | 2248 | 100 | |

Source: Author's elaboration

corresponds to different years: 2009, 2010, 2011, 2013, 2017, 2018, and 2023.[1] The databases are sourced from different research projects financed by different projects, focusing on the economy of small-scale farmers and producers (see Table 1.1).

Defining the variables and characterizing their statistical properties is crucial for this study conducted in Yucatan. This research presents unique data that deepens our understanding of the significant loss of agrodiversity within the Milpa and Solar systems in rural areas. The data, collected from various surveys conducted over several years, are presented in Tables 1.2 and 1.3.

### *1.8.1 Dependent Variable All-Crops*

Given the interest to study agrodiversity on farm (*in situ*) at the level of small-scale farmer household, the number of farmer varieties or local crops is used as a simple measure of richness, that is, a count of the number of crops that the household plants in the Maya Milpa and Solar system. This count of crops is used as the dependent variable in the regression model. Table 1.2 illustrates the different crops in the sample mean of 8.18 crops by household (with as 7.08 standard deviation).

### *1.8.2 Explanatory Variables for Poisson Model*

The age of the household head, or farmer, is an indicator of risk attitudes. Older farmers may tend to be more conservative and risk-averse. They may also possess better knowledge of local landraces and be more willing to plant them (Bellon et al., 2006). Age is included in this assessment to determine whether older farmers are conserving diversity because of traditional practices, tastes, or preferences.

[1] The author holds ownership and property rights for the cross-sectional surveys presented here.

**Table 1.2** Definition of variables: a descriptive statistic

| Variable | Description | Sample mean | Standard deviation |
|---|---|---|---|
| *Dependent variable* | | | |
| Crops milpa | Number of different crops in Milpa | 1.604 | 2.185 |
| Crops solar | Number of different crops in Solar | 6.591 | 6.222 |
| All crops | All the different crops (Milpa + Solar) | 8.176 | 7.083 |
| *Independent variable* | | | |
| Household head's age | Age of the milpa farmer in number of years | 48.495 | 14.786 |
| Household head's education | Number of years of schooling of milpa farmer | 5.203 | 3.927 |
| Household head's sex | 1 = if is man, 0 otherwise | 0.891 | 0.312 |
| Household size | Number of people residing in household | 4.379 | 2.031 |
| Milpa | 1 = if the household has milpa, 0 otherwise | 0.510 | 0.500 |
| Solar | 1 = if the household has solar, 0 otherwise | 0.896 | 0.305 |
| Beekeeping | 1 = if the household has beekeeping, 0 otherwise | 0.113 | 0.316 |
| Rain | Rain average in the research area in Yucatan by year in mml | 977.37 | 419.25 |
| Temperature | Temperature average in research area in Yucatan by year in °C | 26.24 | 1.353 |
| Public policy programs | Number of public policy programs by household | 1.76 | 1.386 |
| Distance | Distance to the permanent market (Mérida) in kilometers | 115.673 | 53.447 |

Source: Author's own elaboration

**Table 1.3** Definition of variables and a descriptive statistic by Milpa farmer

| Description | Milpa farmer | Otherwise | $\|t\|$-value |
|---|---|---|---|
| All crops (Milpa + Solar) | 10.32 | 5.94 | 15.40 |
| Crops in Solar | 7.28 | 5.87 | 5.42 |
| Age of the milpa farmer in years | 49.45 | 47.5 | –3.12 |
| Number of years of schooling of Milpa farmer | 4.73 | 5.69 | 5.82 |
| Number of people residing in household | 4.65 | 4.10 | 6.45 |
| 1 = if the household has Solar, 0 otherwise | 0.95 | 0.84 | 8.69 |
| 1 = if the household has beekeeping, 0 otherwise | 0.17 | 0.05 | 8.83 |
| 1 = if the household has access to rainforest (monte) | 0.0.81 | 0.63 | 9.40 |
| Number of public policy programs by household | 2.15 | 1.36 | 14.03 |
| Distance to the permanent market in kilometers | 125.83 | 105.11 | 9.36 |

Source: Author's elaboration

Household head's education. This variable is measured by the number of years of schooling. The sign of this variable is expected to be negative if the farmer plants a traditional Milpa system, which is not knowledge-demanding. This traditional farming system is typically passed down from parents to children like an inheritance.

Household size, or family size, can influence the maize variety choice via household labour supply decisions (Doss, 2003; Hintze et al., 2003). Additionally, Bekele and Drake (2003) and Bellon and Risopoulos (2001) noted that a large family size is generally associated with a greater labour force available to the household, which can facilitate the timely operation of activities including the adoption of new technologies.

Distance plays a crucial role as an indicator of potential connections between a community and a key nodal town, which is included as an indicator of potential linkages to the regional and national economies. The underlying rationale is that farmers in communities closer to a key town can interact more easily with these regional national economies, as transportation costs are probably lower. Abdulai and Huffman (2005) confirm that households closer to markets are more likely to adopt new agricultural technologies than their counterparts in isolated areas, as a measure of transaction costs.

Beekeeping, particularly stingless beekeeping with species like *Melipona beecheii*, holds significant importance in the traditional Maya Milpa system. The Milpa, a rotational agroforestry system involving the cultivation of maize, beans, and squash, depends on biodiversity and ecological balance. Beekeeping contributes to this system by enhancing pollination, which is essential for the productivity and genetic diversity of both wild and cultivated plants.

"The integration of beekeeping into the Milpa system exemplifies a symbiotic relationship where bees enhance crop yields through pollination, while the diverse flora of the Milpa provides bees with nectar and pollen" (Quezada-Euán, 2018). Furthermore, stingless bees hold a significant place in Maya culture, symbolizing resilience and sustainability, and their honey is used for medicinal, ceremonial, and nutritional purposes (Villanueva-Gutiérrez et al., 2005).

Beekeeping also supports ecosystem services such as biodiversity conservation and soil fertility. As Toledo et al. (2003) emphasize the connection between apiculture and traditional agroforestry systems, such as the milpa. This relationship highlights the role of Mayan knowledge in maintaining ecological integrity and promoting sustainable livelihoods.

Rain is a critical factor in the functioning and sustainability of the Maya Milpa system, a traditional agroforestry practice that relies on seasonal rainfall for crop growth and ecological balance. In the absence of irrigation infrastructure, the success of the Milpa largely hinges on the timely arrival and adequate distribution of rain during the growing season.

"The Milpa system's reliance on rain highlights the deep connection between agricultural practices and local climate conditions, with rainfall determining planting cycles, crop yields, and soil fertility" (Ford & Nigh, 2015). Seasonal rains not only hydrate crops like maize, beans, and squash but also support the surrounding

biodiversity, which, in turn, contributes to pollination and pest control within the Milpa system.

Rainfall is deeply interwoven with Maya culture and spirituality, as evidenced by ceremonies dedicated to *Chaac*, the Maya rain god. These rituals reflect the community's recognition of rain's pivotal role in sustaining both agriculture and life (Re Cruz, 1996). Additionally, variations in rainfall patterns due to climate change pose significant challenges, threatening the resilience of this ancient agricultural system (Vásquez-Mendoza et al., 2020).

Temperature plays a crucial role in the functionality and productivity of the Maya Milpa system, an agroforestry practice that relies on ecological harmony and climate conditions. Optimal temperature ranges are essential for the germination, growth, and maturation of staple crops such as maize, beans, and squash. "The Milpa system is particularly sensitive to temperature changes, as deviations from the norm can impact crop phenology, water demand, and soil microbial activity" (Ford & Nigh, 2015). High temperatures can exacerbate water loss through evapotranspiration, leading to drought stress in crops. Conversely, low temperatures during critical growth stages can delay or inhibit crop development.

Temperature also influences the ecological balance of the Milpa system, affecting the behaviour and population dynamics of pollinators, pests, and beneficial organisms (Altieri, 1995). Furthermore, climate change-induced shifts in temperature patterns pose significant challenges to the sustainability of the Milpa system. Prolonged heatwaves or unusual cold spells can disrupt traditional planting cycles and reduce yields (Vásquez-Mendoza et al., 2020). To adapt to these temperature fluctuations, traditional practices have emerged, such as adjusting planting dates and selecting resilient crop varieties, reflecting the deep environmental knowledge of Maya communities.

Lastly, agricultural public policy programs play a vital role in supporting the sustainability and resilience of the Maya Milpa system, a traditional agroforestry practice central to food security and cultural identity in the Yucatán Peninsula. These programs can provide resources, technical assistance, and financial incentives to help preserve this system amid environmental and socio-economic challenges.

"Public policies that promote agroecological practices and respect for indigenous knowledge are essential for maintaining the ecological balance and productivity of the Milpa system" (Altieri & Nicholls, 2017). Programs designed to support crop diversification, soil conservation, and water management align closely with the principles of the Milpa, ensuring its continued viability.

However, poorly designed policies prioritizing industrial agriculture or monocropping can undermine the Milpa system by promoting practices that deplete soil fertility and reduce biodiversity (Toledo et al., 2003). Instead, targeted policies that provide subsidies for traditional seed varieties, recognize communal land tenure, and encourage sustainable practices can empower Maya communities. These measures would help them preserve their agricultural heritage while adapting to modern challenges.

Additionally, policies that address climate change mitigation and adaptation are critical, as the milpa system is vulnerable to changing rainfall patterns, rising temperatures, and extreme weather events (Vásquez-Mendoza et al., 2020). Integrating traditional knowledge with contemporary scientific approaches in public policy can enhance the resilience of the milpa system and strengthen its role in regional food systems.

Table 1.3 presents the variables, specifically focusing on smallholder households in Milpa. A Student's *t-test* revealed highly significant differences between the characteristics of smallholder households in Milpa and those in "any other activity." These variables enhance the robustness of the *Poisson* econometric model.

The independent variables used in the econometric model highlight significant differences between households that produce Milpa and those that do not. For instance, the average age of Milpa producers is 49.5 years, and they have completed an average of 4.73 years of formal education, indicating that most have not completed primary education. Additionally, Milpa producers are more actively involved in beekeeping activities, including honey production and maintaining apiaries, than their non-producing counterparts. This increased activity not only contributes to the pollination of the Milpa but also encourages economies of scale. Furthermore, special attention is given to the differences in public policy programs that affect these households.

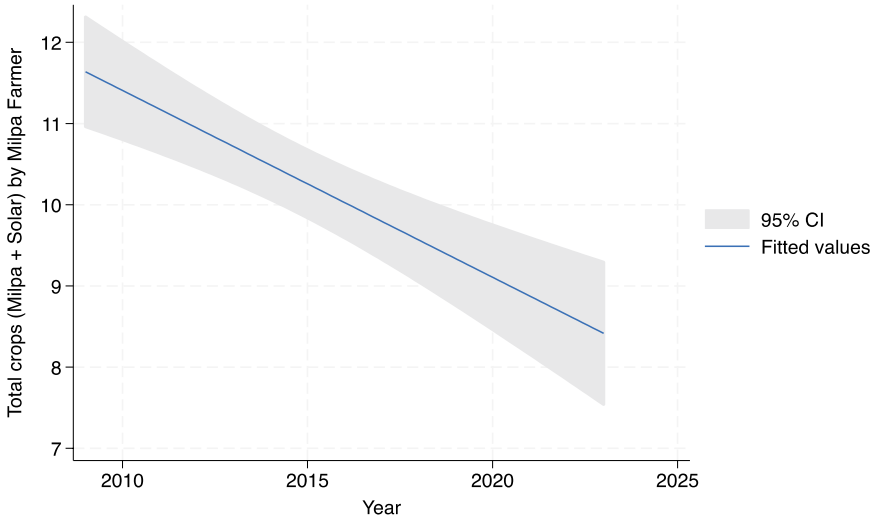
Lastly, we examined the distance in kilometers from households to Mérida, the capital of Yucatán, and the main commercial center. The analysis revealed a statistically significant difference in the distance travelled by households engaged in Milpa production compared to those involved in other economic activities.

The database provides an in-depth analysis of the average number of different crops cultivated by small Milpa producers from 2009 to 2023. The data on "all different crops" per Milpa producer indicates a concerning trend: there has been a decline in the total number of distinct crops grown. This finding serves as the primary motivation for the concerns addressed in this study. It is important to note that the analysis is based on seven observations, utilizing the same survey format for consistency.

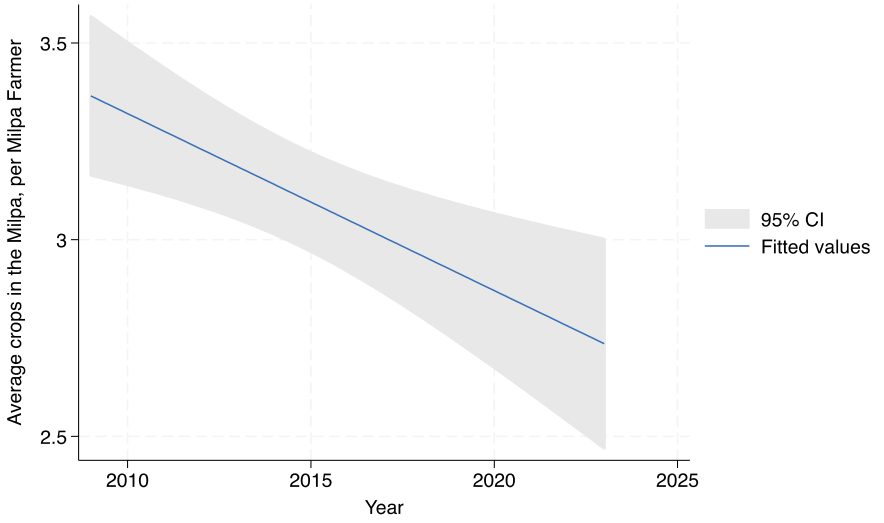
Graph 1.2 illustrates the significance of the dependent variable in this analysis, highlighting a notable loss of agrodiversity among all crop varieties managed by small subsistence producers within the Milpa and Solar production systems.

STATA®'s two-way graphs show the relationship between numeric data. The data shows significant results from a quantitative analysis spanning 13 years, employing cross-sectional designs to detail the evolution of all crop varieties on the Maya and Solar farmers' households:

Graph 1.3 shows the loss of landrace maize diversity in Mexico and Yucatán. Mexico is recognized as the center of origin and domestication of maize (*Zea mays*). It is home to a rich diversity of landrace varieties closely linked to cultural heritage, food security, and agroecosystems. However, in recent decades, this diversity has faced significant threats due to agricultural intensification, market pressures, and climate change.




**Graph 1.2** Dependent variable, all crops (Milpa + Solar) by Milpa farmers. Source: Author's elaboration




**Graph 1.3** Dependent variable, Milpa crops by Milpa farmer. Source: Author's elaboration

In Yucatán, traditional Milpa systems have been the primary method for cultivating maize landraces, which support biodiversity and ecological resilience. However, the introduction of hybrid and open-pollinated varieties (OPV), along with policy shifts that favour industrial agriculture, has led to the displacement of these traditional varieties (Bellon et al., 2003). This erosion of genetic diversity undermines

maize's adaptability to local climatic and soil conditions, reducing its resilience to pests, diseases, and environmental changes.

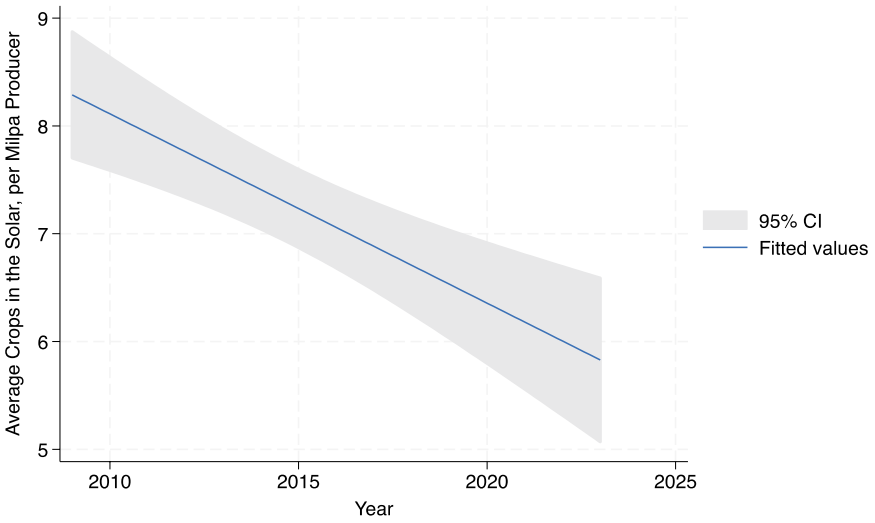
Cultural factors also contribute to this loss, as younger generations increasingly adopt non-traditional farming methods and diets (Brush, 2004). Additionally, economic pressures to maximize yields often incentivize farmers to replace diverse landraces with high-yield commercial varieties. In the Yucatán region, where maize is a staple food and an essential part of local Maya Cosmovision, the decline in traditional maize cultivation poses a threat not only to biodiversity but also to cultural identity (Perales et al., 2003).

Efforts to conserve maize diversity include the establishment of seed banks, participatory breeding programs, and policies supportive of traditional farming systems. These initiatives recognize the importance of landraces as a genetic reservoir, crucial for global food security and the preservation of local cultures.

The findings indicate a loss of landrace maize diversity in the study area in Yucatán (Graph 1.3), which aligns with the existing literature.

In this context, agricultural diversity within Solar Maya has significantly declined over the years and across the studied areas in Yucatán. The findings are summarized in Table 1.6 and illustrated in Graph 1.4. Both components serve as reliable evidence to support the study, highlighting the importance and relevance of the loss of agrodiversity. This also addresses the research question regarding the factors that explain and contribute to the conservation of Milpa and Solar Maya, which exemplifies a sustainable agroecological model.

The age of small-scale farmers practicing Milpa in Yucatán has changed significantly over the past few decades, reflecting broader demographic, economic, and cultural shifts within rural communities. Traditionally, Milpa farming was a




**Graph 1.4** Dependent variable, number of different crops in Solar by Milpa farmers. Source: Author's elaboration

multi-generational practice, with younger family members learning from their elders as part of their cultural and agricultural heritage. However, the aging population of Milpa farmers is now a growing concern.

Studies show that younger generations are increasingly moving away from traditional farming, seeking opportunities in urban areas or other industries, such as those in Mérida, or Cancun resorts and beaches in Riviera Maya. This rural exodus has left Milpa farming largely in the hands of older generations. The average age of Milpa farmers in Yucatán has steadily increased, with many practitioners now over 50 years old, as younger people are less inclined to engage in this labour-intensive and low-income activity (Terán & Rasmussen, 1994).

Several factors contribute to this trend, including limited economic incentives, the perception of farming as a less prestigious occupation, and the challenges posed by climate change, such as unpredictable rainfall and soil degradation (Aide & Grau, 2004). Additionally, the expansion of commercial agriculture and urbanization has reduced the availability of land and resources for traditional farming practices.

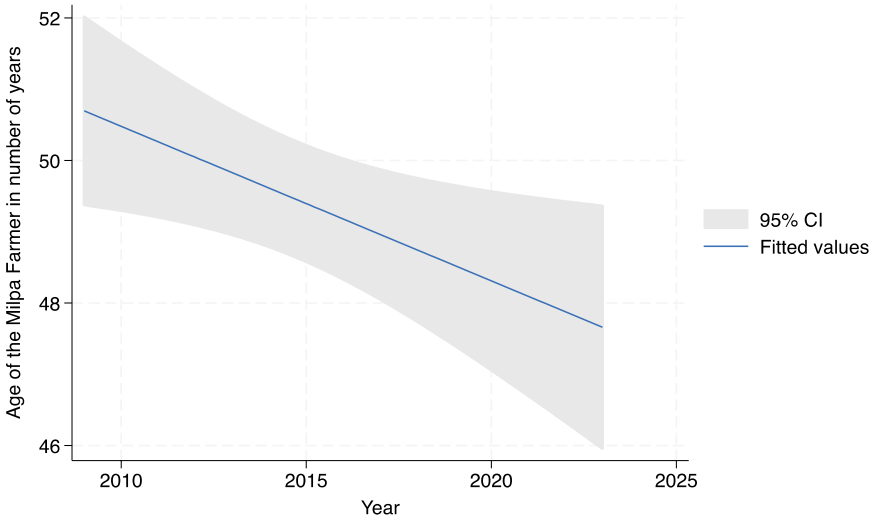
This demographic shift presents risks to the in-situ conservation of the Milpa system, which heavily depends on the knowledge and experience of elderly farmers. The growing disconnection of younger generations from this practice threatens both agricultural sustainability and the transmission of cultural knowledge. To address this issue, efforts are being made to promote programs that provide economic support, education, and incentives for younger farmers to engage in Milpa cultivation (Lopez-Carr et al., 2012). The findings presented in Table 1.4 and Graph 1.5 illustrate these issues.

The formal education of Milpa small-scale farmers in the Yucatán study area has undergone significant changes over time, shaped by broader shifts in rural education access, government policies, and socio-economic conditions. Traditionally, Milpa farming was based on experiential and oral knowledge passed down through generations, with minimal dependence on formal education. However, as access to education in rural areas has expanded, the educational profiles of Milpa farmers have evolved.

**Table 1.4** Mean age of Milpa farmers in Yucatán (2009–2023)

| Year | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| 2009 | 50 | 52.1 | 15.74 | 20 | 86 |
| 2010 | 206 | 52.10 | 14.19 | 21 | 86 |
| 2011 | 139 | 49.35 | 14.42 | 22 | 98 |
| 2013 | 256 | 48.29 | 13.35 | 19 | 87 |
| 2017 | 226 | 49.05 | 13.79 | 18 | 88 |
| 2018 | 85 | 48.84 | 11.40 | 26 | 78 |
| 2023 | 174 | 48.20 | 14.81 | 19 | 85 |
| Total/average | 1136 | 49.45 | 13.98 | 18 | 98 |

Source: Author's elaboration




**Graph 1.5** Age of the Milpa farmer in number of years. Source: Author's elaboration

Historically, many Milpa farmers in rural Yucatán had little to no formal education due to a lack of infrastructure and a cultural emphasis on agricultural practices over schooling. "In the mid-20th century, rural education systems in Yucatán were sparse, with most farmers relying on traditional knowledge for agricultural practices" (Terán & Rasmussen, 1994). As educational opportunities have expanded—particularly through government programs like CONAFE (National Council for Educational Development)—younger generations of farmers have begun to acquire basic literacy and numeracy skills.

Despite these advances, there is still a significant gap between the level of formal education and the needs of modern agriculture. Many Milpa farmers today have only primary or, at most, secondary education, which often does not include training in sustainable agriculture or agroecological practices. This limitation has hindered their ability to adapt to challenges, such as climate change, market integration, and land use pressures (Lopez-Carr et al., 2012).

On the other hand, the preservation of the Milpa system continues to rely heavily on Maya and traditional knowledge, which is typically excluded from formal education. Recent initiatives have sought to bridge this gap by incorporating traditional ecological knowledge into rural education curricula and training programs. "Integrating formal education with traditional practices is key to ensuring the sustainability of the milpa system and empowering farmers to address modern agricultural challenges" (Altieri & Nicholls, 2017).

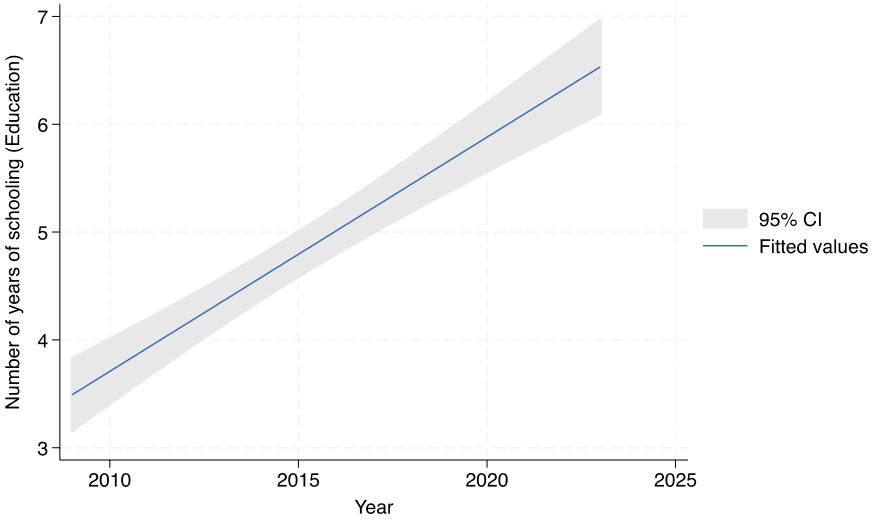
Table 1.5 and Graph 1.6 illustrate the significant changes, transitioning from no primary education to completing primary school or receiving more formal education.

The family size of small-scale Milpa farmers in the Yucatán study area has changed significantly over time, influenced by demographic shifts, economic

**Table 1.5** Mean education of Milpa farmers in Yucatán, 2009–2023

| Year | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| 2009 | 50 | 4.42 | 3.74 | 0 | 14 |
| 2010 | 208 | 3.64 | 2.98 | 0 | 14 |
| 2011 | 145 | 3.86 | 3.42 | 0 | 17 |
| 2013 | 253 | 4.00 | 3.89 | 0 | 16 |
| 2017 | 226 | 5.19 | 3.59 | 0 | 16 |
| 2018 | 85 | 6.87 | 3.28 | 0 | 16 |
| 2023 | 175 | 6.27 | 3.59 | 0 | 16 |
| Total/average | 1142 | 4.73 | 3.68 | 0 | 17 |

Source: Data from different projects




**Graph 1.6** Education and number of years of schooling of Milpa farmer. Source: Author's elaboration

pressures, and cultural transformations. Historically, larger families were common in rural Yucatán, with family members playing a central role in agricultural labour. The traditional Milpa system relies heavily on manual labour, so having more children provided additional help for essential tasks such as planting, weeding, and harvesting (Terán & Rasmussen, 1994).

In the mid-twentieth century, the average family size among Milpa farmers in Yucatán typically included more than five or six members. This trend was supported by cultural norms that valued large families and recognized the economic benefits of having children in subsistence farming. However, in recent decades, demographic changes, including declining fertility rates and increased access to family planning, have contributed to a reduction in family size (Lutz & Samir, 2010).

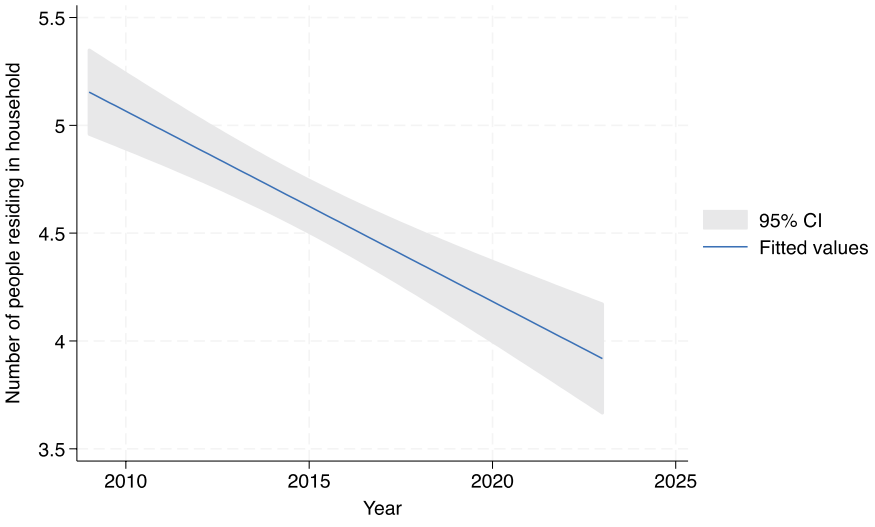
The trend of smaller family sizes has significant implications for the Milpa system. With fewer family members, less labour is available, making it challenging to maintain traditional Milpa practices that depend on intensive manual work. As noted by Faust et al. (2004), "The decline in family size has forced many Milpa farmers to adapt by reducing the area cultivated, adopting labour-saving technologies, or relying on hired labour."

The shift toward smaller families also reflects broader societal changes, such as higher education levels, urbanization, and the migration of younger generations to cities like Merida or Cancun in search of non-agricultural employment. These trends have further weakened the intergenerational transmission of traditional Maya agricultural knowledge, which poses a risk to the sustainability of the Milpa system. Table 1.6 and Graph 1.7 show the decreasing family sizes in the study area in Yucatán.

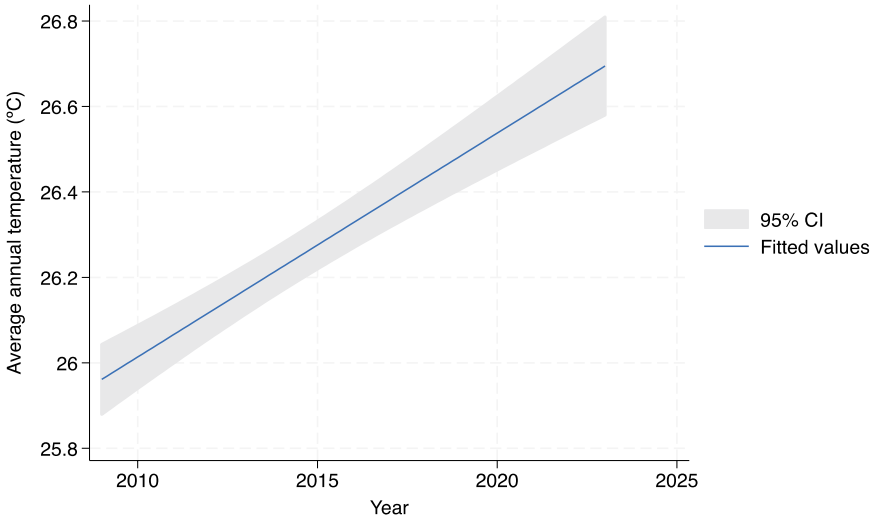
**Table 1.6** Family size of Milpa farmer (2009–2023)

| Year | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| 2009 | 50 | 4.64 | 2.38 | 1 | 10 |
| 2010 | 208 | 4.73 | 2.02 | 1 | 11 |
| 2011 | 140 | 5.09 | 2.22 | 1 | 13 |
| 2013 | 256 | 5.31 | 2.43 | 1 | 15 |
| 2017 | 226 | 4.33 | 1.85 | 1 | 11 |
| 2018 | 85 | 4.22 | 1.60 | 2 | 9 |
| 2023 | 174 | 3.85 | 1.62 | 1 | 10 |
| Total/average | 1139 | 4.65 | 2.11 | 1 | 15 |

Source: Author's elaboration




**Graph 1.7** Number of people residing in household. Source: Author's elaboration




**Graph 1.8** Average temperature (°C) in the research area in Yucatan. Source: Author's elaboration

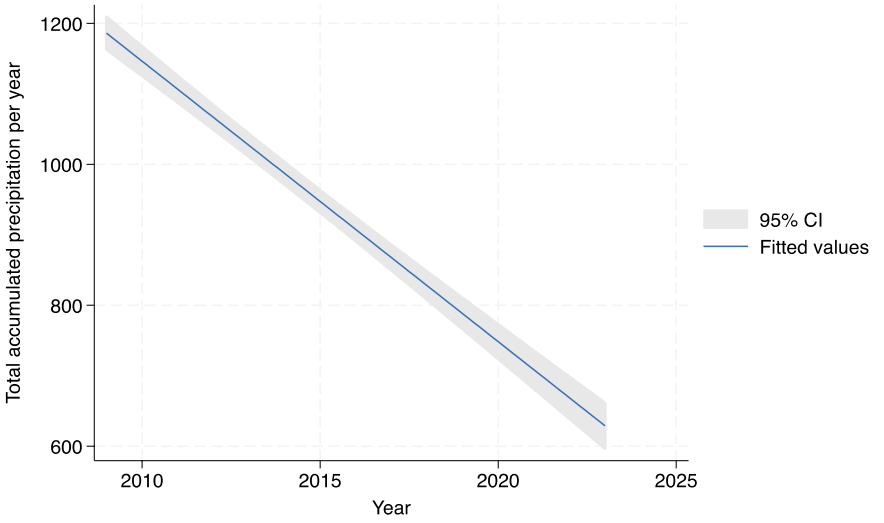
The Milpa system has increasingly been affected by rising temperatures associated with climate change (refer to Graph 1.8). Historically, this system was well-adapted to the climatic patterns of Yucatán, with planting and harvesting cycles aligned with seasonal rhythms. However, rising temperatures have disrupted these cycles, posing significant challenges to crop productivity and sustainability.

Higher temperatures exacerbate heat stress on agrodiversity (maize, beans, and squash), in the Milpa system. This issue is especially pronounced during critical growth stages, like flowering. Research indicates that when temperatures exceed 30–35 °C, maize yields decline due to issues with pollination and kernel formation (Lobell et al., 2011). Additionally, warmer conditions have led to an increase in pests, like the fall armyworm (*Spodoptera frugiperda*), as well as diseases that thrive in heat-stressed environments (Rosenzweig et al., 2001).

Rising temperatures negatively affect soil health by accelerating the degradation of organic matter and reducing soil fertility. Combined with shorter growing seasons caused by quicker crop maturation, these changes threaten the long-term viability of the Milpa system.

Graph 1.8 shows the increase in temperature over the last 13 years in the study area in Yucatán. The data comes from the "*Comisión Nacional del Agua*" and "*servicio meteorológico nacional*," covering different years and averaged at the municipality level. This highlights the actual rise in temperature in the study areas (https://smn.conagua.gob.mx/es/).

The Milpa farming system relies heavily on predictable rainfall patterns. Historically, the region's seasonal rainfall dictated the timing of planting and harvesting cycles. However, climate change has disrupted these patterns, resulting in increased variability in precipitation, prolonged droughts, and intense but irregular rainfall events. All these factors negatively impact Milpa production.




**Graph 1.9** Total accumulated precipitation (rainfed) per year in Yucatan. Source: Author's elaboration

Periods of insufficient rainfall stress essential crops like maize, beans, and squash, which are integral to the Milpa system. Prolonged droughts, particularly those recorded in recent decades, lead to decreased soil moisture, resulting in lower germination rates, stunted growth, and significant yield losses (Reinsch et al., 2024). Conversely, intense rainfall events can cause soil erosion and nutrient leaching, further diminishing productivity (Altieri & Nicholls, 2017).

This variability in rainfall has also disrupted traditional agricultural practices based on stable weather cycles. As a result, farmers are forced to adjust planting schedules or reduce the area they cultivate, which undermines the sustainability of the Milpa and Solar systems (local agrodiversity), as agroecological system de-facto.

Graph 1.9 shows the decrease in rainfed precipitation over the last 13 years in the study area of Yucatán. The data is sourced from the "*Comisión Nacional del Agua*" and the "*servicio meteorológico nacional*," covering different years and averaged at the municipality level. This clearly demonstrates the significant decrease in rainfall amounts (https://smn.conagua.gob.mx/es/).

Lastly, rural producers in Mexico play a crucial role in maintaining evolutionary processes within agricultural ecosystems, particularly through the cultivation of maize (*Zea mays*). According to Bellon and Brush (1994), these producers act as stewards of genetic diversity by continuously selecting, managing, and exchanging maize varieties within traditional farming systems. This practice sustains the dynamic evolutionary interaction between crops and their environments, a phenomenon Bellon refers to as "evolutionary services" (Bellon et al., 2018).

Traditional maize farmers contribute to in situ conservation, ensuring that maize populations remain adapted to diverse and changing local conditions. These farmers enhance the crop's adaptability and resilience by selecting seeds based on traits

such as drought tolerance, pest resistance, and yield stability. These evolutionary services become increasingly important in the context of climate change and shifting agricultural pressures, as they provide the genetic resources necessary for breeding programs and global food security (Bellon & Brush, 1994).

The collaboration between farmers' traditional knowledge and Mexico's ecological diversity enables the continuous evolution of maize. This ensures that maize landraces remain viable for future generations, preserving not only agricultural biodiversity but also cultural heritage. According to Bellon et al. (2018), "the role of farmers in maintaining evolutionary services is fundamental to the sustainability of agroecosystems and the global maize supply."

The small-scale Milpa farmers are not exempt from the impacts of climate change. Their selection of seeds, drawn from a wide range of agricultural diversity, and their cultivation practices, cycle after cycle, contribute to evolutionary services.

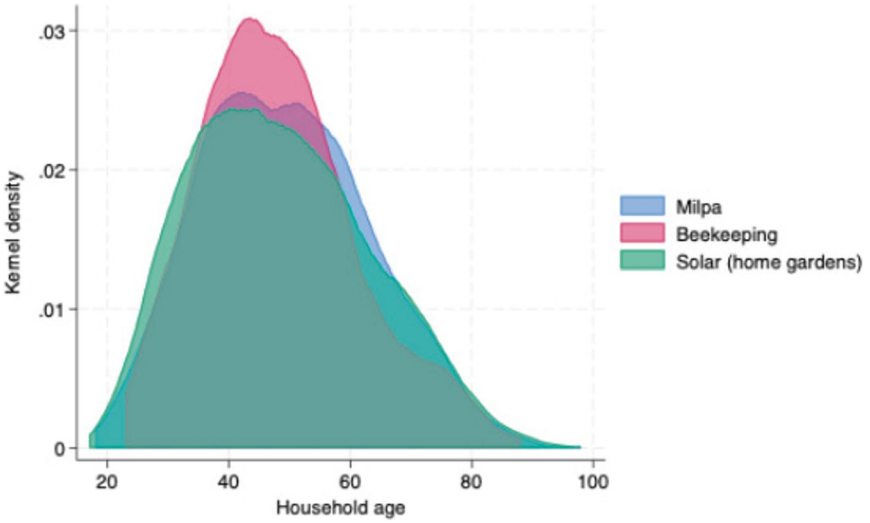
## 1.9 Empirical Results

This cross-sectional econometric analysis examines seven observations spanning 13 years, involving 2248 smallholder households across 96 villages. It aims to address several key questions, including the following: Who are the actors involved in agroecological transformations? Are they peasants, families, communities, or the government? What factors contribute to the maintenance of agroecology in situ? Additionally, what influences the loss of sustainable agroecology and agricultural diversity?

### *1.9.1 The Findings*

The results show an inter-annual average of 50.93 years of age in Milpa producers, with a standard deviation of 13.92 years, which has had an average increase of 2 years of formal education, rising from 4 to 6 years of study on average. In terms of family size, there has also been a decrease in the number of people in the milpa household, from 4.5 to 3.6 people. Although the number of crops planted in the milpa system has fluctuated considerably, the overall trend has been to reduce the number of crops that the household grows.

As seen in Graph 1.10, the age distribution of household heads involved in agroecological activities (Milpa, beekeeping, and Solar) is largely concentrated between the ages of 35 and 60. It is worth noting that the management of the plot of land is traditionally attributed to older adults; on the other hand, Milpa, being a labour-intensive activity, is no longer typically carried out by people nearing 80 years of age. Finally, in the case of beekeeping, the majority of participants fall within the age range of 30–60 years.




**Graph 1.10** Age distribution by economic activity. Source: Author's elaboration

### *1.9.2 Poisson Econometric Model Results (Table 1.7)*

The variables or parameters used in the *Poisson* econometric model have the expected signs and are statistically significant. The marginal effects (see Table 1.8) indicate the potential changes associated with each variable. For example, an increase in the age of the agricultural producer, an additional year of formal education, an increase in distance to the main commercial center by 1 km, an annual loss of agrodiversity, or a temperature rise all have notable impacts. The analysis results are robust and systematic, effectively addressing the questions posed at the outset of this study.

The size of small-scale farmers' households influences the number of crops they can cultivate in their Milpa, depending on their consumption needs and labour. This, in turn, is affected by the age and gender of the family members, as well as their stage of family life. The amount and organization of multiple family activities also play a role, contingent on the number, age, and gender of the individuals involved. While the nuclear family comprising father, mother, and children is the basis of the family, the extended family formed by aunts, uncles, cousins, and grandparents has been central to family life because it is an important resource when additional labour is needed. Close family friends and additional acquaintances are another potential labour resource.

**Table 1.7** Generalized negative binomial regression

| All crops | Coef. | St.Err. | *t*-value | *p*-value | [95% Conf Interval] | | Sig |
|---|---|---|---|---|---|---|---|
| Hh head's age | 0.008 | 0.001 | 5.99 | 0.000 | 0.005 | 0.011 | *** |
| Hh head's education | 0 | 0.005 | –0.01 | 0.992 | –0.01 | 0.01 | |
| Hh head's sex | 0.135 | 0.058 | 2.32 | 0.02 | 0.021 | 0.249 | ** |
| Hh size | 0.02 | 0.009 | 2.26 | 0.024 | 0.003 | 0.038 | ** |
| Beekeeping | 0.383 | 0.055 | 6.99 | 0.000 | 0.276 | 0.491 | *** |
| Public policy programs | 0.032 | 0.014 | 2.27 | 0.023 | 0.004 | 0.06 | ** |
| Temperature (°C) | –0.048 | 0.015 | –3.14 | 0.002 | –0.079 | –0.018 | *** |
| Rain (mml) | 0.000 | 0.000 | –5.31 | 0.000 | 0.000 | 0.000 | *** |
| Distance | 0.002 | 0.000 | 6.24 | 0.000 | 0.002 | 0.003 | *** |
| Year | –0.023 | 0.005 | –4.97 | 0.000 | –0.032 | –0.014 | *** |
| Constant | 48.444 | 9.149 | 5.29 | 0.000 | 30.512 | 66.376 | *** |
| Constant (lnalpha) | –0.615 | 0.039 | –15.95 | 0.000 | –0.69 | –0.539 | *** |
| Mean dependent var | 8.209 | SD dependent var | | | 7.093 | | |
| Pseudo r-squared | 0.016 | Number of obs | | | 2207 | | |
| Chi-square | 222.420 | Prob > chi2 | | | 0.000 | | |
| Akaike crit. (AIC) | 13,597.181 | Bayesian crit. (BIC) | | | 13,665.574 | | |

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$
Source: Author's elaboration of a database of different cross-sections from 2009 to 2023

**Table 1.8** Generalized negative binomial regression: Marginal effects

| Variable | dy/d*x* | Std. err. | *z* | *P* > *z* | [95% C.I.] | | *X* |
|---|---|---|---|---|---|---|---|
| Hh head's age | 0.065 | 0.011 | 5.970 | 0.000 | 0.043 | 0.086 | 48.500 |
| Hh head's education | –0.000 | 0.042 | –0.010 | 0.992 | –0.082 | 0.081 | 5.226 |
| Hh head's sex | 1.015 | 0.414 | 2.450 | 0.014 | 0.203 | 1.827 | 0.894 |
| Hh size | 0.161 | 0.071 | 2.260 | 0.024 | 0.021 | 0.300 | 4.375 |
| Beekeeping | 3.544 | 0.590 | 6.010 | 0.000 | 2.387 | 4.700 | 0.115 |
| Public policy programs | 0.253 | 0.112 | 2.270 | 0.023 | 0.034 | 0.472 | 1.754 |
| Temperature (°C) | –0.383 | 0.122 | –3.140 | 0.002 | –0.623 | –0.144 | 26.231 |
| Rain (mml) | –0.002 | 0.000 | –5.300 | 0.000 | –0.003 | –0.002 | 972.628 |
| Distance | 0.019 | 0.003 | 6.220 | 0.000 | 0.013 | 0.026 | 115.150 |
| Year | –0.180 | 0.036 | –4.950 | 0.000 | –0.251 | –0.109 | 2014.270 |

Source: Author's elaboration of a database of different cross-sections from 2009 to 2023

## 1.10 Conclusion

This chapter aims to answer the research questions in depth: Who are the actors of agroecological transformations? (peasants? family? community? state/government?) What factors contribute to maintaining agroecology in situ? Additionally, what factors influence the loss of sustainable agroecology and its agricultural diversity?

The key contributors to the continuity and conservation of native varieties (*criollo*) within the Milpa Maya and Solar system, as well as a diverse range of agricultural, agroecological, and agroforestry practices, are small subsistence producers. These producers, primarily elderly men, also engage in honey production from both native and European bee species. Public policy programs related to the Milpa agricultural sector have played a significant and positive role in the long-term continuity and conservation of these practices. However, various factors threaten local agrodiversity, including historical trends, distance to major commercial centers, rising temperatures, and disruptions in rainfall patterns.

The conservation of agrodiversity in the Milpa and Solar systems in Yucatán promotes access to healthy, nutritious, and sufficient food for the poor sectors of the region, including small-scale farmers and their families. This is especially relevant today, considering the health problems that not only the Maya population but also the world population presents today in relation to obesity, diabetes, and malnutrition.

An integrated socio-economic analysis that considers environmental, economic, and social systems allows us to understand the changes in the dynamics around the Milpa. This understanding enables the design of effective and well-focused public policies to preserve the biocultural richness of the agroecological system and minimize the exogenous effects caused by the global changes of the economy, which have been intensified by climate change.

## Appendix (Table 1.9)

**Table 1.9** Survey of municipality by year (2009–2023)

| | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Municipality | 2009 | 2010 | 2011 | 2013 | 2017 | 2018 | 2023 | Total |
| Acanceh | 68 | 0 | 0 | 0 | 0 | 0 | 0 | 68 |
| Cantamayec | 0 | 0 | 0 | 2 | 18 | 0 | 14 | 34 |
| Cuzama | 85 | 0 | 19 | 0 | 0 | 0 | 0 | 104 |
| Chacsinkin | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 23 |
| Chankom | 0 | 0 | 20 | 0 | 17 | 16 | 20 | 73 |

(continued)

**Table 1.9** (continued)

| | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Municipality | 2009 | 2010 | 2011 | 2013 | 2017 | 2018 | 2023 | Total |
| Chemax | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 |
| Chikindzonot | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 7 |
| Dzilam Bravo | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 19 |
| Espita | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 |
| Hocaba | 0 | 59 | 0 | 0 | 0 | 0 | 0 | 59 |
| Hoctun | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 7 |
| Homun | 73 | 0 | 0 | 0 | 0 | 0 | 0 | 73 |
| Huhi | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 21 |
| Hunucma | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 |
| Iamal | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 |
| Kanasin | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 19 |
| Mama | 0 | 0 | 0 | 0 | 12 | 11 | 15 | 38 |
| Mani | 0 | 0 | 0 | 0 | 29 | 19 | 18 | 66 |
| Maxcanu | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 |
| Mayapan | 0 | 0 | 0 | 0 | 20 | 0 | 8 | 28 |
| Merida | 0 | 0 | 40 | 0 | 0 | 0 | 0 | 40 |
| Motul | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 19 |
| Muna | 0 | 0 | 2 | 39 | 0 | 0 | 0 | 41 |
| Muxupip | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 16 |
| Oxkutzcab | 0 | 0 | 20 | 96 | 0 | 0 | 0 | 116 |
| Rio Lagartos | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 20 |
| Santa Elena | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 22 |
| Sotuta | 0 | 0 | 0 | 0 | 7 | 0 | 28 | 35 |
| Sucila | 0 | 42 | 0 | 0 | 0 | 0 | 0 | 42 |
| Tahdziu | 0 | 0 | 0 | 0 | 20 | 0 | 11 | 31 |
| Teabo | 0 | 0 | 0 | 0 | 7 | 0 | 14 | 21 |
| Tekax | 0 | 20 | 20 | 132 | 0 | 0 | 0 | 172 |
| Tekom | 0 | 0 | 0 | 0 | 7 | 9 | 42 | 58 |
| Tepakan | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 18 |
| Ticul | 0 | 0 | 21 | 0 | 0 | 3 | 57 | 81 |
| Tinum | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 20 |
| Tixcacalcupul | 0 | 0 | 0 | 0 | 7 | 30 | 14 | 51 |
| Tixmehuac | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 6 |
| Tizimin | 0 | 0 | 20 | 129 | 0 | 0 | 0 | 149 |
| Tzucacab | 0 | 230 | 0 | 0 | 7 | 0 | 0 | 237 |
| Valladolid | 0 | 0 | 19 | 0 | 0 | 1 | 0 | 20 |
| Yaxcaba | 0 | 0 | 0 | 0 | 142 | 34 | 118 | 294 |
| Total | 247 | 371 | 392 | 420 | 313 | 123 | 382 | 2248 |

Source: Author's elaboration of a database of different cross sections from 2009 to 2023

## References


Abdulai, A., & Huffman, W. (2005). The diffusion of new agricultural technologies: The case of crossbred cow technology in Tanzania. *American Journal of Agricultural Economics, 87*(3), 645–659. https://doi.org/10.1111/j.1467-8276.2005.00753.x

Aide, T. M., & Grau, H. R. (2004). Globalization, migration, and Latin American ecosystems. *Science, 305*(5692), 1915–1916. https://doi.org/10.1126/science.1103179

Altieri, M. A. (1995). *Agroecology: The science of sustainable agriculture*. CRC Press.

Altieri, M. A., & Nicholls, C. I. (2017). *Agroecology: A transition to sustainable food and agriculture systems*. CRC Press.

Avalos-Rangel, M. A., Campbell, D. E., Reyes-López, D., Rueda-Luna, R., Munguía-Pérez, R., & Huerta-Lara, M. (2021). The environmental-economic performance of a Poblano family milpa system: An energy evaluation. *Sustainability, 13*(16), 9425. https://doi.org/10.3390/su13169425

Baños Ramírez, O. (2000). La península de Yucatán en la ruta de la modernidad (1970–1995). *Revista Mexicana del Caribe, 5*(9), 164–190.

Bekele, W., & Drake, L. (2003). Soil and water conservation decision behavior of subsistence farmers in Eastern Highlands of Ethiopia: A case study of the Hunde Lafto area. *Ecological Economics, 46*, 437–451. https://doi.org/10.1016/S0921-8009(03)00166-6

Bellon, M. R., Adato, M., Becerril, J., & Mindek, D. (2006). Poor farmers' perceived benefits from different types of maize germplasm: The case of creolization in lowland tropical Mexico. *World Development, 34*(1), 113–129. https://doi.org/10.1016/j.worlddev.2005.05.012

Bellon, M. R., & Brush, S. B. (1994). Keepers of maize in Chiapas, México. *Economic Botany, 48*, 196–209. https://doi.org/10.1007/BF02908218

Bellon, M. R., Mastretta-Yanes, A., Ponce-Mendoza, A., Ortiz-Santamaría, D., Oliveros-Galindo, O., Perales, H., Acevedo, F., & Sarukhán, J. (2018). Evolutionary and food supply implications of ongoing maize domestication by Mexican campesinos. *Proceedings of the Royal Society B: Biological Sciences, 285*(1885), 20181049. https://doi.org/10.1098/rspb.2018.1049

Bellon, M. R., Pham, J. L., & Jackson, M. T. (2003). Genetic conservation: A role for rice farmers. *Biodiversity & Conservation, 6*(1), 83–90. https://doi.org/10.1007/978-94-009-1437-7_17

Bellon, M. R., & Risopoulos, J. (2001). Small scale farmers expand the benefits of improved maize germplasm: A case study from Chiapas, Mexico. *World Development, 29*(5), 799–811. https://doi.org/10.1016/S0305-750X(01)00013-4

Brush, S. B. (2004). *Farmers' bounty: Locating crop diversity in the contemporary world*. Yale University Press.

Doss, C. R. (2003). *Understanding farm level technology adoption: Lessons learned from CIMMYT's micro surveys in eastern Africa*. CIMMYT.

Faust, B. B., Gehring, C. A., & Aleman, J. (2004). Land use and land cover change in the Maya area: Linking socioeconomic and environmental variables. *Human Ecology, 32*(3), 291–314.

Fonteyne, S., Castillo Caamal, J. B., Lopez-Ridaura, S., Van Loon, J., Espidio Balbuena, J., Osorio Alcalá, L., Martínez Hernández, F., Odjo, S., & Verhulst, N. (2023). Review of agronomic research on the milpa, the traditional polyculture system of Mesoamerica. *Frontiers in Agronomy, 5*, 1115490. https://doi.org/10.3389/fagro.2023.1115490

Food and Agriculture Organization of the United Nations. (2018). *The 10 elements of agroecology: Guiding the transition to sustainable food and agricultural systems*. FAO.

Ford, A., & Nigh, R. (2015). *The Maya forest garden: Eight millennia of sustainable cultivation of the tropical woodlands*. Routledge.

French, J. H. (1995). *Farm household decision making and extension framework for understanding farm household-level decision making and design of agroforestry extension strategies* (Vol. 1). FAO. https://openknowledge.fao.org/handle/20.500.14283/x0266e

Gliessman, S. R. (2015). *Agroecology: The ecology of sustainable food systems*. CRC Press.

Gobierno del estado de Yucatán. (2020, June 4). Autoridades estatales y productores yucatecos recorren zonas de cultivo afectadas por fuertes lluvias. Gobierno del Estado de Yucatán. http://www.yucatan.gob.mx/saladeprensa/ver_nota.php?id=2936

Gordillo, G. (2004). Los retos del momento actual en el campo. *Economía UNAM, 2*(5), 23–40.

Greene, W. (2020). *Econometric analysis* (8th ed., Global ed.). Pearson.

Hintze, L. H., Renkow, M., & Sain, G. (2003). Variety characteristics and maize adoption in Honduras. *Agricultural Economics, 29*(3), 307–317. https://doi.org/10.1016/S0169-5150(03)00058-6

Jago, S., & Borrell, J. S. (2024). Agrobiodiversity conservation enables sustainable and equitable land sparing. *Trends in Ecology & Evolution, 39*(10), 877–880. https://doi.org/10.1016/j.tree.2024.08.009

Jiménez-Osornio, J. J., Montañez Escalante, P. I., Ruenes Morales, M. d. R., Estrada Medina, H., & Ferrer Ortega, M. M. (2022). La agroecología en el estado de Yucatán. In C. Elizondo, D. López Merlín, & A. Vázquez G (Eds.), *Agroecología en México, soberanía alimentaria, saberes, cosmovisión y patrimonio biocultural: Conocimiento, práctica, movimiento y corazón* (1st ed., pp. 15–24). Editorial Chapaneros y Sociedad Mexicana de Agroecología A.C.

Khoury, C. K., Brush, S., Costich, D. E., Curry, H. A., De Haan, S., Engels, J. M. M., Guarino, L., Hoban, S., Mercer, K. L., Miller, A. J., Nabhan, G. P., Perales, H. R., Richards, C., Riggins, C., & Thormann, I. (2022). Crop genetic erosion: Understanding and responding to loss of crop diversity. *New Phytologist, 233*(1), 84–118. https://doi.org/10.1111/nph.17733

Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science, 333*(6042), 616–620. https://doi.org/10.1126/science.1204531

López Santiago, M. A., Valdivia Alcalá, R., Romo Lozano, J. L., & Cuevas Alvarado, C. M. (2013). Análisis de economías rurales mediante el modelo de hogares agrícolas bajo un equilibrio general. *Econoquantum, 10*(1), 91–113. https://doi.org/10.18381/eq.v10i1.159

Lopez-Carr, D., Sorensen, C., & Kepner, W. (2012). Rural out-migration and agroforestry dynamics in tropical Latin America. *Land Use Policy, 29*(1), 445–455.

Lutz, W., & Samir, K. C. (2010). Dimensions of global population projections: What do we know about future population trends and structures? *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 2779–2791. https://doi.org/10.1098/rstb.2010.0133

Martín Castillo, M. (2016). Milpa y capitalismo: Opciones para los campesinos mayas yucatecos contemporáneos. *LiminaR Estudios Sociales y Humanísticos, 14*(2), 101–114. https://doi.org/10.29043/liminar.v14i2.463

MONGABAY. (2023). Cuatro monocultivos que amenazan los bosques de México. https://es.mongabay.com/2023/01/en-corto-cuatro-monocultivos-que-amenazan-los-bosques-de-mexico/

Nicholls, C. I., Henao, A., & Altieri, M. A. (2015). Agroecología y el diseño de sistemas agrícolas resilientes al cambio climático. *Agroecología, 10*(1), 7–31. https://revistas.um.es/agroecologia/article/view/300711

Perales, H. R., Benz, B. F., & Brush, S. B. (2003). Maize diversity and ethnolinguistic diversity in Chiapas, Mexico. *Proceedings of the National Academy of Sciences, 102*(3), 949–954. https://doi.org/10.1073/pnas.0408701102

Quezada, S., Robles, F. R., & Andrews, A. P. (2014). *Historia general de Yucatán*. Universidad Autónoma de Yucatán.

Quezada-Euán, J. J. G. (2018). *Stingless bees of Mexico: The biology, management, and conservation of an ancient heritage*. Springer. https://doi.org/10.1007/978-3-319-77785-6

Re Cruz, A. (1996). *The two milpas of Chan Kom: A study of gender and intergenerational relations in a Maya community*. State University of New York Press.

Reinsch, S., Robinson, D. A., van Soest, M. A. J., Keith, A. M., Parry, S., & Tye, A. M. (2024). Temperate soils exposed to drought—Key processes, impacts, indicators, and unknowns. *Land, 13*, 1759. https://doi.org/10.3390/land13111759

Rodríguez-Robayo, K. J., Méndez-López, M. E., Molina-Villegas, A., & Juárez, L. (2020). What do we talk about when we talk about milpa? A conceptual approach to the significance, topics

of research and impact of the Mayan milpa system. *Journal of Rural Studies, 77*, 47–54. https://doi.org/10.1016/j.jrurstud.2020.04.029

Rosenzweig, C., Iglesias, A., Yang, X. B., Epstein, P. R., & Chivian, E. (2001). Climate change and extreme weather events. *Global Change & Human Health, 2*(2), 90–104. https://doi.org/10.1023/A:1015086831467

Singh, I., Squire, L., Strauss, J., & World Bank (Eds.). (1986). *Agricultural household models: Extensions, applications, and policy*. Johns Hopkins University Press. http://documents.worldbank.org/curated/en/621291468739297175

Taylor, J. E., & Adelman, I. (1996). *Village economies: The design, estimation, and use of villagewide economic models* (1st ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781139174572

Terán, M., & Rasmussen, R. O. (1994). The milpa system of Yucatán. *Culture & Agriculture, 16*(51–52), 13–21.

Toledo, V. M., Ortiz-Espejel, B., Cortés, L., Moguel, P., & Ordoñez, M. D. J. (2003). The multiple use of tropical forests by indigenous peoples in Mexico: A case of adaptive management. *Conservation Ecology, 7*(3), 9.

van Dusen, E., & Taylor, J. E. (2005). Missing markets and crop diversity: Evidence from Mexico. *Environment and Development Economics, 10*(4), 513–531. http://www.jstor.org/stable/44379248

Vásquez-Mendoza, R. A., Bello, R. C., & Lutz-Ley, A. N. (2020). Climate change impacts on traditional milpa systems in the Yucatán Peninsula. *Journal of Environmental Management, 255*, 109874. https://doi.org/10.1016/j.jenvman.2019.109874

Velásquez García, E., Nalda, E., Gonzalbo, P. E., Martínez, B. G., Hausberger, B., Mazín, Ó., de Estrada, D. T., Marichal, C., Ávila, A., Jáuregui, L., Ortega, J. A. S., Vázquez, J. Z., Lira, A., Staples, A., Ficker, S. K., Guerra, E. S., Garciadiego, J., Aboites, L., Loyo, E., … Meyer, L. (2017). *Nueva historia general de México.* El Colegio de México.

Villanueva-Gutiérrez, R., Roubik, D. W., & Colli-Ucán, W. (2005). Extinction of *Melipona beecheii* and traditional beekeeping in the Yucatán Peninsula. *Bee World, 86*(2), 35–41. https://doi.org/10.1080/0005772X.2005.11417397

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# Chapter 2
# Sustainable Agricultural Practices in Neoliberal Times: An Exploratory Analysis of Integrated Farming Systems, India

**Archana Prasad and Praveen Jha**

**Abstract** It is well recognized that one of the impacts of neoliberal policies has been the deepening socio-economic and ecological crisis in Indian agriculture. The persistence of this crisis over the last three decades has led to contemporary debates on sustainable alternatives; internationally, the themes of this debate have assumed importance in the wake of the SDG 2030 Agenda. This chapter intervenes in the debate through an exploratory analysis of the potential of integrated farming systems to deal with the agrarian crisis confronting the Indian peasantry. In its essence, such a system is based on the efforts to upgrade the existing farming systems through the creation of synergies between economic and ecological dimensions of agricultural production. The chapter argues that integrated farming interventions have the potential to move towards the objectives of Agenda 2030, but they have been largely ignored by a neoliberal state.

**Keywords** Neoliberalism · Agroecology · Sustainability and peasentry

## 2.1 Introduction

The historic peasant protests of 2021 revealed the growing contradiction between corporate agribusiness and the peasantry, a tension that has developed since the introduction of neoliberal agrarian reforms in the 1990s. These reforms facilitated market-dominated and integrated rural semi-proletariat into corporate-dominated global agricultural markets by developing globalized agricultural value systems (Jha & Yeros, 2019). This was accompanied by the diminishing role of state

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investment (Jha & Acharya, 2009), which had earlier been a countervailing force for protecting the marginal and small peasantry against domination of big business and landlords. However, its absence not only increased the dependence on exploitative markets but also deepened the crisis of social reproduction in agrarian societies (Jha & Mishra, 2022; Prasad et al., 2023). This forced the proponents of the neoliberal policy reforms to recognize the importance of addressing the interlinkage between economic crisis and ecological concerns arising out of climate change (Bathla et al., 2020; Chand, 2019).

Though the debate on sustainable alternatives has a long history, state-led initiatives have virtually ignored the possibility of market regulation and state investments, even while addressing the problem of ecology through the promotion of zero-budget natural farming (CSE, 2020). Here, it is important to emphasize that the Government of India's latest initiative was influenced by the FAO's Agenda 2030, which focused on the development of agroecological models as alternatives to unsustainable and emission-inducing agricultural practices. This was reflected in India's official responses to the Agenda, where it identified both integrated farming and organic farming as part of its innovation systems to move towards climate-resilient agriculture (Chand, 2023). However, the programs promoted by the government in response to the agenda are not new and have a prior history in debates on sustainable alternatives to models of high external input agriculture.

This chapter intervenes in the debate through an exploratory analysis of the potential of integrated farming systems to deal with the above-mentioned agrarian crisis confronting the Indian peasantry. In its essence, such a system is based on the efforts to upgrade the existing farming systems through the creation of synergies between the economic and ecological dimensions of agricultural production. This is done by combining scientific interventions with locally available resources and the expertise of the peasants and rural workers. At present, about 0.1 million farmers practice integrated farming in India, whose expansion and monitoring is largely a result of an All India Coordinated Project on Integrated Farm Systems, which has been funded by the Indian Council of Agricultural Research (ICAR) over the last decade and a half (Gupta et al., 2021: 58) We use the reports of this project and the available secondary material to explore whether such a farming system can combat the problems confronting the Indian peasantry today.

The paper is divided into four sections: the first section provides a brief history of the initiatives and perspectives on sustainable alternatives in agriculture. The second section provides a brief snapshot of the long-term impact of the long-term economic and ecological crisis on the rural semi-proletariat. It does this in the particular context of the impact of neoliberal policy reforms and the deepening crisis of social reproduction. The third section explores the potential of integrated farming systems to confront this crisis; it does this in a comparative framework vis-à-vis the government's zero-budget natural farming initiative. The paper ends with some concluding remarks.

## 2.2 Brief History of Sustainable Alternatives in Agriculture

Debates on the sustainability of high external input agriculture have a long history and can be traced back to the critique of the industrial revolution itself. For example, the destruction of nature with large-scale industrialization and the conversion of large common lands into private property were iconically opposed by the romantics, who created an image of humans living in harmony with nature in eighteenth-century Europe. However, it was with Henry David Thoreau that we first had the most vivid writings on the intimate workings of nature and its oneness with human beings. Described as a "naturalist," Thoreau propelled the imagination of the unity and wholeness of the "natural world"; this idea focused on the interdependence of all living organisms as a fundamental principle of a harmonious world (Worster, 1977: 58–76). This was accompanied by the development of ecology as a science, and its institutionalization in the 1930s and 1940s, particularly to aid the colonial harnessing of natural resources in the colonies. Notable among the scientists who helped to institutionalize colonial ecology were Charles Darwin, Francis Bacon, and their contemporaries (Crosby, 1986; Diamond, 1999; Grove, 1995). While we do not wish to get into a detailed discussion of this long history, we mention it here in order to make two important points: first, the development of ecology as a science was closely related to the development and expansion of capitalism and second, ideological opposition to and protest against such an enterprise was often embedded in the idea that humans should respect the rights of nature and live in harmony with it. Such a debate also informed scientific critiques of industrial input-based chemical agriculture, and argued for environmental controls over the use of harmful inputs (Carson, 1962; Levins, 2020).

This broad spectrum of diverse ideas was complex but had significant implications for contemporary debates on the destructive impact of capitalist accumulation on nature and the people who depend on it, particularly with reference to agriculture. In India, this issue was recognized and debated from the early twentieth century onwards, as national leaders debated the developmental path the country should take after gaining independence. In his famous treatise, *Hind Swaraj*, Mahatma Gandhi outlined his vision for self-sufficient and self-governing villages where land would belong to the tiller, and chemical-free agriculture would be practiced in harmony with nature (Iyengar, 2022). This idea was further developed in to an agrarian program for rural reconstruction by J.C. Kumarappa, who envisaged a farming system that would be based on the use of resources available in the "current economy," where supply is relatively unlimited, and the preservation of the resources in the "reservoir economy" whose non-renewal resources had to be preserved (Kumarappa, 1951: p. 8). Such use would ensure "non-violent" methods of agricultural production, which would hurt neither humans nor nature. Producers would own their own land and resources, and use organic agricultural inputs to provide sufficient healthy food through cooperative production. In particular, Kumarappa emphasized the importance of chemical-free agriculture and soil health when he wrote, "that it is better for us to be content with a smaller crop while remaining within the range of recovery of *soil fertility*" (Kumarappa, 1951: 19).

However, this strategy did not advocate for restructuring production through the redistribution of land, land reforms, and the taxation of large businesses, as proposed by the People's Plan authored by M.N. Roy (Patnaik, 1998). Kumarappa's critique of American methods of agriculture was not compatible with the dominant vision of the planners in Independent India, who sought to align agricultural development with the goals of achieving self-reliant industrialization and self-sufficiency in foodgrains. The first plan focused on expanding cultivation through public investments in infrastructure and community development programs. Following some initial success in reaching record agricultural production, this focus quickly shifted to the development of big industry through public investments in capital goods, as outlined in the Mahalanobis plan. While the plan included an important section on land reforms and agriculture and nominally promoted cooperative farming, there was a significant lack of political will to effectively implement this progressive agricultural strategy. Rather, as Chakravarty (1987: p. 21) puts it, the second plan saw it necessary to emphasize that "it was necessary for agriculture to contribute to the building up of a modern industrial sector by providing cheap labour and also cheap food."

The early plans primarily focused on maintaining and enhancing agricultural productivity by promoting high-yielding varieties and establishing a publicly funded agrarian research system dedicated to testing these varieties and developing fertilizer and input packages. The research was funded through public funding, as well as by externally aided projects from American agencies such as the Rockefeller Foundation and Ford Foundation (Abrol, 1983). The resulting Green Revolution strategy was supported by the state through significant investments in public infrastructure and an agricultural extension system that promoted high-input agriculture.

However, this strategy faced opposition within the system of agricultural research. Scientists like Richaria, the director of the Rice Research Institute in Cuttack, advocated for an alternative method of cloning local seeds to increase productivity. However, his dissent was overruled, and the prevailing agricultural extension system promoted high-input agricultural practices aimed at achieving both high productivity and sustainable yields. Agricultural research also supported this strategy by developing agronomic packages and farming systems tailored for these practices. In the 1950s and 1960s, the ICAR coordinated the first all-India project focused on conducting simple fertilizer trials and exploring agronomic practices in different climatic zones[1] (AICPR-IFS, 2015: p. 10). Models of high-input industrial agriculture have been questioned and contested since the introduction of high-yielding varieties during the Green Revolution.

The Green Revolution is widely recognized for achieving record yields and significantly enhancing food security in India. However, it also has social, economic, and ecological consequences that impact the long-term socio-economic sustainability of livelihoods. Declining yields and falling incomes have been attributed to

[1] Agroclimatic zones were classified by the Indian Council of Agricultural Research on the basis of soil types, topography, and climatic conditions. Each zone was divided into sub-zones. They were also classified by National Bureau of Soil Science and Land Use Planning; but this classification was different from the one done by ICAR. Thereafter the Planning Commission classified India into 15 agroclimatic zones with 72 sub-zones in 1988. The ICAR-Indian Institute of Farm Systems Research (ICAR-IIFSR) uses this classification in its annual report.

deteriorating soil health caused by unsustainable cropping patterns. This model has led to reduced soil fertility, primarily due to the repeated use of chemical fertilizers and pesticides (Goswami et al., 2018; Shiva, 2016). Further, the increased use of machinery, pesticides, and other industrial inputs had negatively impacted both the health of the land and the well-being of farmers. These included rising accidents through the shift to extensive use of machinery, adverse impact of increased use of pesticides on the quality of output and water, the rise in pollution because of burning of residues, among others (Goswami et al., 2018; Jha et al., 2019; Shiva, 2016). These challenges have sparked a new wave of debates on alternative farming models, many of which draw inspiration from the Gandhian principles of organic farming, where farmers are encouraged to forego all external inputs (particularly chemical ones).[2]

By the 1980s, educated youth and some farmers with access to resources started practicing organic farming, especially with export-oriented crops. This movement was spearheaded mainly by non-governmental organizations such as Navdanya and Deccan Development Society. By 2000, about 14,000 tonnes of organic fruits, pulses, wheat, and other products were produced by farmers, of which 11,695 tonnes were exported (Narayanan, 2003: pp. 55–56). These initiatives greatly influenced the subsequent development of organic and natural farming networks, particularly regarding the movement towards sustainable agriculture.[3]

Though a detailed discussion of these factors is beyond the scope of this chapter, we want to emphasize that these initiatives primarily targeted niche markets that had begun to recognize the adverse impact of excessive chemical fertilizers and pesticides on consumer health (Jha et al., 2019; Mittal et al., 2014).

In this context, it is important to recognize that the Indian agricultural research system was not entirely unaware of developments related to sustainable alternatives in agriculture. In the 1980s, some ICAR institutes shifted their focus towards strategies aimed at improving farmers' incomes through cropping systems research. To facilitate this, the Directorate of Cropping Systems Research was established at Modipuram (Uttar Pradesh) to oversee a coordinated project aimed at developing sustainable packages for improved ecological and economic management of cropping systems. By 2009–10, this directorate was renamed the Project Directorate for Farming Systems, with a clear aim to intervene in the livelihood strategies of marginal and small farmers. One of the main objectives of the project was to characterize specific farming systems through on-farm research and develop ecologically and economically sustainable agricultural models for these small and marginal farmers. This two-pronged approach resulted in the development of a knowledge repository regarding farmers' practices, while also conducting trials to enhance their farming systems (AICRP-IFS, 2018).

From 1988 to 2010, the All India Coordinated Research Project on Cropping Systems mapped the existing farming systems by documenting the relationship

[2] For examples on these see Srivastava and Kothari (2014).

[3] There are several organizations linked to international networks for organic and low external input agriculture like Low External Input and Sustainable Agriculture Alliance, Alliance for Sustainable Agriculture, and others.

between farming and other income-generating activities followed by marginal/small farmers across 14 agroclimatic zones identified by the Planning Commission in 1988. The objective was to enhance local livelihood systems and improve them through technical interventions.[4] This data was generated from the Project Directorate for Cropping Systems Research at Modipuram, which was established in 2003–04 to coordinate the All India Coordinated Research Project on Cropping Systems, which implemented an integrated farming system approach specifically aimed at supporting marginal and small farmers. By 2014, the project directorate became a fully funded institute under the ICAR, known as the Institute of Integrated Farming Systems Research (IIFSR). The institute's mandate is to conduct "basic and strategic research on integrated farming systems on production technologies for improving productivity and resource use efficiencies." It also aims to "develop efficient, economically viable and environmentally sustainable integrated farming system models for different farming situations" and create a "repository of information on all aspects of farming systems research and development" (IIFSR, 2015: p. 16). The institute's work is focused on creating models for field trials and on-farm research for marginal and small farmers. The first phase of this work was conducted from 2010 to 2017–18, focusing on implementing strategic on-farm and off-farm interventions to establish economically sustainable models for small farms. During this period, several on-farm trials were conducted and monitored between 2011–12 and 2017–18. In the second phase, which took place from 2018–19 to 2022–23, the focus shifted to developing climate-smart strategies for these sites.

The new project, titled "All India Coordinated Research Project on Integrated Farming Systems," continues the strategy established in the 2017–18 project, but with some revised objectives. These include the identification of "ecologically and economically viable enterprises for different regions under climate change scenario," "resource budgeting in systems perspective with special reference to soil, water, nutrients and energy," development of "low carbon production modules," and to explore "secondary agriculture avenues in farming systems" to attract younger generation to agriculture (AICRP-IFS, 2023: p. 33). These objectives were to be implemented by adding a few sites and reclassifying agro-climatic zones, which was completed in 2021. The first phase focused on developing economically viable models through diversification, while the ecological benefits largely resulted in cost savings. The older sites from the 2017 to 2018 period continued to report their results

[4] In total it mapped about 38 different components available for marginal farmers to integrate different livelihood strategies with farming. However, 58% of the marginal/small households only integrated two components (i.e., cropping with livestock). About 41% of households engaged in integrated farming with livestock/poultry or fisheries; only a small portion of these households integrated more than three components in their livelihood strategies. In each of these cases, the major portion of the income came from cropping, which was facing increasing cost of production, decreasing productivity, worsening soil health, and depleting groundwater resources. The annual income of those who depended on cropping and livestock averaged about INR 57,000 from 0.82 ha, whereas those who integrated more than two components had an annual income of about INR 1.61 lakhs per year from 0.84 ha (IIFSR, 2015: pp. 9–10). This analysis implied that combining farming and other non-farm operations was helpful for farmers, and a holistic intervention was needed to augment farmers' income.

but needed to modify their data collection strategies to align with the revised objectives.

Though we will discuss the strategy results later, it is important to emphasize that the second phase of the program was developed as an integrated strategy of establishing the relationship between economic and ecological sustainability of the marginal and small farmers. Scientific studies argue that, in its essence, the strategy created a multitiered system with complementary livelihood strategies. According to Singh and Ravisankar, integrated farming is a "judicious mix of two or more components using cardinal principles of minimum competition and maximum complementarity with advanced agronomic management tools aiming for sustainable and environment-friendly improvement of farm income, family nutrition and ecosystem services" (cited in Panwar et al., 2018: p. 70).

In essence, the IFS models adopt some of the principles of agroecology, as promoted by the FAO in its Agenda 2030 for Sustainable Agriculture. These principles include promotion of diversity, co-sharing and co-creation of knowledge, creation of synergies between different components of farming and other agricultural landscapes, efficiency of resource use, recycling, resilience through risk management, responsible governance, promotion of local food heritage, promotion of circular economy, and the emphasis on human and social values promoting equity and inclusion (Altieri, 1995; FAO, 2013: p. 11; Gliessman, 2015). The IFS strategy conceptualizes its strategic interventions based on some of these principles, particularly regarding the integration of farming within the agricultural landscape, efficient resource use, promotion of diversity, recycling, and resilience. However, it also differs in certain aspects, such as its focus on local markets and complete reliance on a circular economy. Instead, the focus is on a resilient farming system that requires low external inputs and has the potential to provide farmers with some independence from market fluctuations. Unfortunately, this perspective has not found its legitimate place in India's response to Sustainable Development Goals Agenda 2030; it has only received a formal mention in the response to the FAO Agenda 2030 (Chand, 2023).

Although the IFS trials are state-funded and have a widespread focus and scope, it is important to recognize that policymakers have not fully recognized their full potential, primarily due to the state's neoliberal policy orientation. The neoliberal policy reforms introduced in the 1990s were envisaged as a solution to the problems arising out of the long-term impact of the Green Revolution strategy, which had promoted a high external input system of agriculture. As is well known, the Green Revolution significantly contributed to achieving self-sufficiency in foodgrain production and meeting food security needs (Bhalla, 2017). However, there were diminishing returns, particularly after the mid-1980s, leading to a trajectory of declining yields and falling income of farmers (Frankel, 2015; Goswami et al., 2018; Magdoff & Tokar, 2010). These trends were attributed to the negative impacts of high-input-based agriculture on soil health and the water table (Bakker et al., 2020; Jha et al., 2019; Shiva, 2016), as well as to exacerbating inequality within the agrarian society (Bhalla, 2017; Frankel, 2015; Goswami et al., 2018; Jha & Mishra, 2022).

There are different perspectives on the root causes of the agrarian crisis. Conventional agricultural economists and policymakers attribute these trends to "government and market failures" (Bathla et al., 2020; Chand, 2019; Gulati et al., 2021), which resulted from a lack of competition due to state monopolies over procurement. This, in turn, led to lower incomes for farmers and increasing levels of indebtedness. It is important to recognize that this viewpoint laid the groundwork for neoliberal agrarian reforms. However, these reforms did not address one of the root causes of the agrarian crisis, namely, the degradation of productive forces. Instead, policymakers advocated reforms aimed at connecting farmers to open, deregulated markets to help them increase their incomes (Goswami et al., 2018; Gulati et al., 2021). But the available evidence suggests that the removal of restrictions on imports from the early 1990s was aimed at integrating farmers into global markets. As a result, international trade in agricultural products has shown an upwards trend, with India becoming one of the largest importers of vegetable oils and pulses. Between 2012–13 and 2023–24, India's agricultural exports increased from US $41.7 billion to US $48.8 billion, while agricultural imports rose from US $19.7 billion to US $32.7 billion during the same period (Damodaran, 2025). This shift resulted in a decline in the trade surplus for agricultural products, which declined from US $21.8 billion in 2012–13 to US $16.1 billion in 2023–24, marking a reduction of more than 25% over a decade.

The increasing reliance on import dependence is a result of falling public expenditure and a policy orientation that promotes the expansion of corporate agribusiness in rural areas (Jha et al., 2022; Prasad et al., 2023). Despite policymakers claiming that an export-led strategy would address the problems of stagnating production and declining farm incomes, this form of market integration has had a devastating impact on the overall well-being of Indian farmers and agricultural workers. The government has been responding to the contemporary crisis by collating existing organic farming experiments under the National Sustainable Agriculture Mission, which promotes Zero Budget Natural Farming (ZBNF) as a sustainable alternative. Therefore, it is essential to compare the results of the IFS strategy with both conventional agriculture and ZBNF. This comparison highlights the importance of the much-neglected IFS in resolving the challenges faced by the Indian farmers.

## 2.3 Brief Snapshot of Impact of Conventional Agriculture and Market Integration

There are multiple sources to assess the impact of corporate-driven, high external input-driven farming systems on marginal and small farmers. The Agricultural Census, the National Sample Survey Organisation's (NSSO) Situation Assessment of Farmers, NSSO's All India Debt surveys, and the National Bank of Agricultural and Rural Development's (NABARD) surveys on rural indebtedness, all provide valuable data. Although these sources use different methods and reveal some varying trends, they also highlight the increasing vulnerability and destruction of the livelihoods of semi-proletarianized marginal and small peasants.

Since the mid-1990s, approximately 400,000 farmers have committed suicide due to falling incomes and rising indebtedness. In 2022 alone, 5207 farmers, 6083 agricultural workers, and 45,194 daily wage workers died by suicide due to agrarian distress (NCRB, 2023: p. 239). This tragic situation can be summarized by a few stylized facts that highlight the rural crisis that has persisted for more than three decades. First, the per capita availability of cereals and food grains for domestic consumption has been on a declining trend since the early 1990s. According to estimates by Utsa Patnaik, by the year 2017–18, about 80% of the rural population in India was unable to meet its nutritional needs, consuming less than 2400 calories per day (Patnaik, 2024a). Furthermore, this decline in food intake is closely related to the decreasing purchasing power of the rural population (Patnaik, 2024b).

Second, Patnaik's conclusion is corroborated by recent surveys and studies on the income trends of agricultural households. According to surveys conducted by India's premier statistical agency, the NSSO, the average monthly income of an agricultural household increased from INR 2115 in 2002–03 to INR 6426 in 2012–13 and INR 10,218 in 2018–19 (NSSO, 2014, 2021). However, this increase in agricultural incomes was not due to improved earnings from agricultural production. In fact, the percentage of income derived from crop cultivation declined from 46% of total household income in 2002–03 to 36% in 2018–19. This decline reflects the growing challenges faced by farmers, including rising input costs, fluctuating market prices, and deteriorating climatic conditions (Roy & Terway, 2024: p. 869).

This trend impacted different classes of farming households in varying ways. Those with less than 1 hectare of operational land, which make up about two-thirds of the peasantry, earned an average monthly income of INR 8110; 52% of this income came from wage labour. Furthermore, more than 60% of the marginal farmers, who relied heavily on their livelihood, were enrolled in the publicly funded rural employment guarantee program, providing them only 100 days of guaranteed employment each year. In contrast, large farming households with more than 10 ha of land reported an average monthly income of INR 60,758 (Roy & Terway, 2024: p. 870). Two recent studies conducted by NABARD,[5] including the All India Rural Financial Inclusion Survey (NAFIS) for 2016–17 and 2020–21, indicate that the average monthly income of agricultural households increased from approximately INR 8931 in 2016–17 to INR 13,661 in 2020–21. It is also important to highlight that crop production from sharecropping accounted for only 33–35% of the total monthly income during the entire period under consideration (NABARD, 2017: p. 22; 2021: p. 31).

Third, related to both the above-mentioned trends is the growing indebtedness of the peasantry because of declining incomes. Surveys conducted by the NSSO in 2013 and 2019 reveal that, though the proportion of agricultural households in debt remained between 50 and 52% during these periods, the amount of loans has increased. Specifically, the average debt per agricultural household rose from approximately INR 47,000 in 2013 to INR 74,121 (NSSO, 2014: p. 23; 2021: p. ix). The NAFIS surveys present a concerning trend regarding the average debts of farmers. The percentage of agricultural households in debt increased from about 52.5%

[5] National Bank for Agriculture and Rural Development is a bank setup by the central government to finance agricultural development.

in 2016–17 to 55% in 2020–21. Regarding average debt, agricultural households had approximately INR 104,000 in 2016–17, which decreased to approximately INR 91,000 in 2020–21. Additionally, the outstanding loans for agricultural households in 2020–21 ranged from approximately INR 85,000 to 150,000 (NABARD, 2017: p. 23; 2021: p. xxxiii).[6] Although both NABARD and NSSO provide differing estimates of indebtedness, they demonstrate that the policy reforms aimed at addressing the issues faced by marginal and small farmers are leading to a significant burden of debt.

The above-mentioned devastating impact of the government's response prompted several protests by the peasants and workers (Jha, 2024; Jha & Prasad, 2020). At the same time, the pressures from multilateral agencies highlighted the need for climate-resilient agriculture to address the issues of rising hunger and the depletion of drinking water resources. For instance, the Intergovernmental Panel on Climate Change pointed out in its Sixth Report (2022) that in 2022 the NDA government launched the National Mission for Natural Farming (NMNF), with the main objective of promoting ZBNF. This initiative was based on the Andhra Pradesh model of traditional agroecology, which emphasizes farming without any external inputs. Instead, it relies on the traditional use of organic seeds and fertilizers, drawing on knowledge from the "Indian knowledge system." However, studies conducted by scientists both within and outside the Indian agricultural research system have shown that this model of natural farming is neither ecologically nor economically viable (ICAR-CRIDA, 2020), but instead of following the scientists' advice, the government issued guidelines that recommended seeking further technical assistance from companies and other external "experts" to make the system viable. Needless to say, the state would provide subsidies to support the scaling up of this form of farming. As Abrol has argued, the project's operational guidelines are designed to create a dependency among the semi-proletarianized peasantry on corporate agribusiness and capitalist landlords (Abrol, 2023).

Thus, it can be confidently asserted that the alliance between big business and the Indian state is the driving force behind the officially sponsored program of sustainable agriculture. The condition of the Indian peasantry can be characterized as a state of semi-proletarianization, where large sections of the population have been forced to become part of an ever-expanding labour reserve, providing cheap wage labour to all sections of the corporate world. As seen above, a vast section of this population is experiencing a crisis of social reproduction. This crisis stems from the government's failure to recognize the devastating impact of more than three decades of market deregulation, reductions in public funding for farmers, and indifference to the ecological impact of the Green Revolution strategy. In light of this, it is pertinent to ask the following questions: do the available alternatives to the Green Revolution strategy, such as ZBNF or IFS, have the potential to resolve the crisis of social reproduction faced by the semi-proletarianized peasantry? We aim to answer this question with a particular focus on the marginalized IFS models developed by the ICAR system.

[6] NAFIS 2016–17 just provided an average figure, whereas NAFIS 2020–21 provided figures for all categories of farmers according to their operational landholdings. Hence, the range is only provided for NAFIS 2020–21.

## 2.4 IFS Models, Crisis of Social Reproduction, and Sustainable Agriculture

The previous discussion highlighted that the policy response to the adverse impact of conventional agriculture has been characterized by corporate-driven neoliberal market reforms. Unfortunately, these reforms have only exacerbated the socio-economic and ecological challenges faced by marginal and small farmers (Prasad et al., 2023). Therefore, it is crucial for any alternative development approach to address the fundamental issue of improving the bargaining position of the poor peasantry in markets. This can be achieved by enabling them to reduce their dependence on the market and mitigate their rising indebtedness.

To achieve this goal, it is important that any alternative provides sustainable yields, enhanced incomes, and year-round employment. In this discussion, we will evaluate whether the IFS strategy has the potential to address some of these aspects. We will compare the available data, organized in terms of agroclimatic zones, vis-à-vis the existing literature on ZBNF. The section is divided in three broad subsections: (1) a note on the data sources and methods used to gain some insights, (2) an assessment of ecological stability and resilience, evaluating how IFS and ZBNF can address the question of yields, climate resilience, and diversity; and (3) the economic impacts on income, employment, and labour, particularly addressing the issue of sustainable livelihoods.

1. *Data, methods, and limitations*: As of 2021, there are about 0.1 million farmers practicing different forms of IFS in 23 zones in 14 agro-climatic zones. These farmers are part of an IFS network coordinated by the ICAR-IIFSR as a nodal agency, which maintains a site-specific database. The reports generated can be divided into two phases of AIRCP-IFS work: the first phase from 2010 to 2017 and the second from 2018 to 2022. This classification is in line with the development of strategic interventions aimed at achieving both ecological and economic sustainability goals in existing farming systems. The changes reflected in the data also illustrate how these strategic interventions have developed over the years.

Broadly speaking, publicly available data can be divided into three time periods, each covering various aspects of socio-economic and ecological indicators. In this chapter, we will focus specifically on the indicative trends related to employment, income, market dependence, and some aspects of ecological sustainability. It is important to emphasize that we do not delve into the technical details of interventions or conduct a detailed analysis of their impact on energy conservation, nutrition, or different components of soil health, which have been studied by different scholars, scientists, and practitioners.[7] Therefore, our evaluation is based on key

[7] For instance see the large body of work by Panwar, Ravishankar and their team at IIFS (Panwar et al., 2018; Panwar, Prusty, et al., 2021; Panwar, Ravishankar, et al., 2021). Also see Ramana et al. (2024); Kumar et al. (2018); Manjunath et al. (2025), among others.

indicators presented in annual reports, using aggregate data organized according to agroclimatic zones (in terms of the 1988 Planning Commission classification).

The classification of agroclimatic zones and sites was tabulated in the following manner:

| Agro-climatic region | Locations (state) | Number of IFS models |
|---|---|---|
| Western Himalaya | Chatha (J&K), Palampur (HP), Pantnagar (UK) | 3 |
| Eastern Himalaya | Umiam (Meghalaya), Jorhat (Assam) | 2 |
| Trans Gangetic Plains | Hisar (Haryana), Ludhiana (Punjab) | 2 |
| Upper Gangetic Plains | Modipuram (UP), Kanpur (UP) | 2 |
| Middle Gangetic Plains | Varanasi (UP), Ayodhya (UP), Patna (Bihar), Sabour (Bihar) | 5 |
| Lower Gangetic Plains | Kalyani (WB) | 1 |
| Eastern Plateau and Hills | Raipur (Chhattisgarh), Ranchi (Jharkhand), Chipilima (Odisha) | 3 |
| Central Plateau and Hills | Jabalpur (MP), Rewa (MP), Durgapura (Rajasthan), Kota (Rajasthan) | 4 |
| Western Plateau and Hills | Akola (MS), Parbhani (Maharashtra), Rahuri (Maharashtra) | 3 |
| Southern Plateau and Hills | Rajenderanagar (Telangana), Coimbatore (TN), Kathalgere (Karnataka), Siriguppa (Karnataka), Maruteru (AP), Rudrur (AP) | 6 |
| East Coast Plains and Hills | Thanjavur (TN), Bhubaneswar (Odisha) | 2 |
| West Coast Plains and Hills | Goa, Karjat (Maharashtra). Karamana (Kerala) | 7 |
| Gujarat Plains and Hills | SK Nagar (Gujarat), Junagarh (Gujarat) | 2 |
| Islands | Port Blair (A&N) | 1 |
| Total | | 43 |

Source: AICRP-IFS (2022–23: p. 33)

Though this classification has been used for the period from 2017–18 to 2022–23, we use the site classification from the latest report because it also includes four additional sites that were added to the project in 2021–22. We have made all data from years prior to 2018–19 comparable with this classification, and any discrepancies in data for particular years are indicated in the tables. Further, the tables created for this paper do not include the Islands agroclimatic zone due to the unavailability of systematic data for that zone during the initial period.

The Researchers' Manual on *Key Performance Indicators*, developed in 2021 by AICRP-IFS (Prusty et al., 2021), is used to define the scope of the analysis and facilitate the extraction of data from annual reports. The parameters outlined in the manual provide some indicative trends regarding the reduction of market dependence, implications for labour, economic resilience, and ecological impacts.

| Parameters | Market dependence | Economic resilience | Impact on labour | Ecological sustainability |
|---|---|---|---|---|
| Indicators ➡ | • Reduction in market inputs in terms of percentage of recycled inputs | • Rate of net returns, i.e., net returns/total cost (including and excluding family labour)<br>• Savings accruing from the reduction of dependence in terms of market inputs<br>• Productivity measured in terms of REY (Rice equivalent yield) | • Labour intensity, i.e., total labour cost/ total cost<br>• Average person days of employment created<br>• Imputed value of family income | • Climate impact in terms of net carbon emissions, i.e., carbon sink in the base year-carbon emissions from each IFS component<br>• Percentage of organic carbon retained and renewed in the soil due to impact of recycled inputs and modification of cropping strategies, indicating impact on soil health |

The data is organized as per the accepted classification of agro-climatic zones, with systematic reports available from 2010 to 2011 onwards. As mentioned earlier, between 1989 and 2010, 39 sites provided data on ecological parameters, but there was little focus on income and patterns of work. The focus of the early reports was primarily on generating data to monitor improvements in soil health and crop yields. From 2010 to 2014, ecological data were supplemented with information on costs, income, and employment. However, the data is presented site-by-site for different agroecological zones, and there are no comparable aggregates provided across these zones.

Systematic data is available on annual employment and income for every model across months. From 2014–15 to 2017–18, the data also included labour costs; however, these labour costs were not disaggregated into hired and imputed cost of family labour. This makes it difficult to understand the dependence of these models on labour markets. Data is available for the following parameters: mean yields of different components, the value of purchased market inputs such as fertilizer, the value of recycled inputs, labour costs, and the total number of person-days of employment created. This information is presented site-wise, detailing specific plot sizes on which interventions were implemented.

The 2017–18 report provides insight into the impact of the early interventions by the IFS in terms of aggregate figures during the first phase of the project, covering the years 2012 to 2017 (AICRP-IFS, 2018). In the analysis, the yields from different interventions on the same farm are combined into a single indicator known as the rice equivalent yield (REY), calculated using a standardized formula that is beyond the scope of this paper. Further, the imputed value of recycled inputs is considered as a saving for farming households, as it reduces their dependence on market-based external inputs. Income data is presented in terms of gross and net incomes, allowing for the calculation of net returns for farmers.

From 2018 to 2019, during the second phase of the project, the data have been systematically organized into zone-wise aggregates. Size-wise aggregates are only provided for total costs of interventions, which serve as the basis for calculating the mean cost for each zone. The different components of the model's costs—such as the cost of hired labour, the cost of market inputs, the imputed cost of family labour, and the value of recycled inputs (excluding family labour)—are presented as percentages of the total mean cost of each zone in a pie chart. Additionally, the zone-wise averages for REYss, person-days of employment generated, gross returns, and net returns are included in the explanations for every zone. Further data is available regarding the aggregate impact on soil health and carbon emissions, from 2019–20 to the latest report, i.e., 2022–23 (AICRP-IFS, 2019, 2020, 2021, 2022, 2023).

As noted above, the averages presented in the paper are only indicative trends that help us assess whether the IFS strategy has the potential to address some of the contemporary challenges faced by the Indian peasantry. It is important to interpret the data presented here with a few caveats. First, adding new sites within a zone can significantly affect the average figures presented. As site-level data for all selected parameters is available in the annual reports, it is not possible to normalize the data by recalculating zonal averages. Hence, if two sites are added to a zone in 2021, the

mean of that zone is likely to decrease. This is because a typical IFS strategy has a gestation period of 2–4 years before it starts to show significant impact. Additionally, all costs and values are calculated based on actual or estimated market prices, which are subject to fluctuations in the open market. When analyzing calculations based on these zonal averages, this variability should be taken into account. Third, although the 2021 manual suggests that data on labour days for activities in the farm have been collected, this data is not available in the annual reports. Hence, it is not possible to draw any conclusions on the labour process within an IFS-based farm. These limitations should be kept in mind when analyzing the indicative trends related to different aspects of the IFS.

2. *Ecological stability and resilience*: One of the primary methods for assessing the ecological stability and resilience of an agricultural system is to evaluate soil health under specific agricultural conditions. According to the FAO, "Soil health has been defined as the capacity of soil to function as a living system. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and weed pests, form beneficial symbiotic associations with plant roots, recycle essential plant nutrients, improve soil structure with positive effects for soil water and nutrient holding capacity, and ultimately improve crop production. A healthy soil also contributes to mitigating climate change by maintaining or increasing its carbon content" (FAO, 2015: p. 1).

In line with these parameters, the GR strategy has encouraged a high-input agricultural approach aimed at enhancing the foodgrain yields. However, this has led to soil depletion, a situation that Karl Marx famously referred to as the "metabolic rift" (Foster, 1999). As Marx and other scholars pointed out, the rift was primarily due to the pressures of the state and markets to increase food production from the late 1950s to the 1970s. Thereafter, the focus shifted to maintaining the profits of rich farmers from the 1970s onwards. This led to the promotion of irrational cropping patterns and the excessive use of urea-based chemical fertilizers, pesticides, and micronutrients to replenish the nitrogen, phosphorus, and potassium content of the soil. The overuse of these chemicals has resulted in the present ecological crisis, as acknowledged in a vast body of existing literature (Abrol, 2020; Hansen, 1988; Jha et al., 2019; Mittal et al., 2014).

Existing experiments with ZBNF have tried to address the escalating ecological crisis by applying "natural" solutions to restore soil health through chemical-free and regenerative agriculture. This approach promotes the application of chemical-free fertilizers, such as *jeevanmithra* (a mixture of cow dung and cow urine), seeds sourced directly from the farm or *beejamithra*, and mulching practices. These methods are rooted in "traditional" agricultural systems and "indigenous" knowledge (CSTEP, 2019; ICAR-CRIDA, 2020). The expected outcomes of this program include increased biodiversity, reduced cultivation costs, production of nutritious food, and higher incomes for farmers.

The first Indian state to promote ZBNF was Andhra Pradesh, which financed hundreds of farmers to adopt this method in September 2015. Subsequently, by 2019–20, the central government launched the Bhartiya Prakritik Krishi Paddhiti

program to expand the implementation of this strategy, including both NMNF and ZBNF in 2022. However, before the launch of this mission, ICAR-CRIDA (2020) studied the impact of ZBNF on soil health across selected sites in three states: Andhra Pradesh, Karnataka, and Maharashtra. The study involved 295 farmers practicing natural farming (NF), and their results were compared with those of 170 farmers practicing conventional farming (non-NF farmers) in 52 villages with different agroecological conditions. The summary of the study's results is as follows:

> On an average, conventional farming (Non-NF) practices tended to show better results in terms of available nutrient status and soil organic C compared to natural farming (NF) fields. It could be due to the reason that Non-NF practices are being practiced for last many years in the study area. Whereas NF practices have been adopted for last 3–4 years only. It was also observed that the populations of most of the groups of microorganisms were higher in Non-NF fields as compared to NF fields. Although, in some cases, level of some micro-nutrients as well as microorganism counts were higher in case of natural farming fields (ICAR-CRIDA, 2020: p. 75).

It appears that ZBNF lacks the capacity to effectively tackle the issue of deteriorating soil health. This strategy relies heavily on the farmers' capacity to resolve their challenges through traditional knowledge and techniques. This conclusion is further corroborated by the ICAR-IIFSR study on ZBNF (Das et al., 2024). In contrast, the IFS does not altogether reject the use of external inputs; rather, it promotes their rational use. As noted by Panwar, Prusty, et al. (2021: p. 1132):

> The basic objective of IFS is to recycle the wastes to reduce the cost on manures and fertilizers and also provide eco-friendly production environment. The IFSs have been designed scientifically at different locations through AICRP-IFS in which various location-specific modules including plantation crops, orchard, dairy, goat, sheep, poultry, fish, pig, apiary, mushroom, biogas, and boundary plantations have been integrated with an aim to meet the household demand of 4Fs (food, fodder, feed and fuel), besides recycling of wastes to meet the nutrient requirement of different components. The recycling was done mainly through preparation of vermicompost (VC) at all the locations besides adding additional components such as Azolla, biogas, etc. to generate nutrients within the farm as much as possible.

The paper presents the results of a strategy implemented across 15 agro-climatic zones and concludes that using recycled inputs led to the generation of natural nutrients in the soil between 2018 and 2020. On average, 1 hectare of land produced 114.9 kg of nitrogen, 51.1 kg of phosphorus, and 81.14 kg of potassium from recycled nutrients. These replaced chemical fertilizers to the tune of 249 kg of urea, 318 kg of single super phosphate (SSP), and 134 kg of muriate potash (MOP) that were typically used in conventional farming methods (Panwar, Prusty, et al., 2021).

The annual reports of the AICRP-IFS for different years, summarized in the tables included in the Appendix, indicate a significant improvement in soil health and agroclimatic conditions. Table 2.1 in the Appendix shows the percentage improvement in organic carbon content in the soil resulting from the IFS interventions. The increase is measured as a percentage rise of organic carbon content over the base year for measurement, which is 2017–18, the year when the current phase of the AICRP-IFS became operational. This means that the use of chemical fertilisers can be reduced if the micronutrients and organic carbon content are enhanced.

As is evident from this table, the degree of improvement varies across different agro-climatic zones and is also influenced by the nature of specific interventions (Panwar, Prusty, et al., 2021; Prusty et al., 2021: p. 19). For example, hilly regions such as Western Himalayan Zone, which focus on horticulture and livestock-based interventions, may experience an improvement to the tune of 20–30%. In contrast, in the plains like the Upper Gangetic Plain, the soil health improvement might be between 9 and 12%. As the table shows, the organic carbon content has improved across all zones between 2019–20 and 2020–23; however, this trend follows a complex and diverse trajectory.

The improvement in soil health also has a positive impact on addressing the issue of $CO_2$ emissions, which contribute to the negative impacts of carbon. This is quantified by net carbon emissions, with detailed data presented in Table 2.2 of the Appendix. Net carbon emissions are calculated by taking total carbon emissions from all IFS activities minus the total greenhouse gas (GHG) emissions and carbon sink recorded in the baseline year, 2017–18 (Manjunath et al., 2025; Prusty et al., 2021, p. 20). Consistent measurements were taken for the years 2019–20 to 2022–23. These measurements indicate that 11 of the 13 zones documented in this paper experienced negative carbon emissions. However, adequate results were not recorded for two zones. The Central Plateau and Hill zone reported positive carbon emissions during the first 2 years of documentation, specifically between 2019 and 2021. Nevertheless, after the initial 2 years of IFS intervention, even this zone recorded negative net carbon emissions. This outcome reflects the potential of the IFS strategy to mitigate the adverse impacts of climate change that the world confronts today.

The main benefit of improvements in soil health seems to have arrested the decline in crop yields following interventions in cropping patterns. Long-term trends in yields since 2012—which is when the AICRP-IFS project began—are measured by converting the production of each component to REY (Prusty et al., 2021: pp. 4–5). The trends for different agro-climatic zones from 2012–13 to 2022–23 are presented in Table 2.3 of the Appendix. With some minor variations, nearly all zones demonstrate an improvement in yield for farmers with operational land holdings of 1 ha or below. This observation is corroborated by the secondary literature, which argues that both cropping intensity and farm productivity may increase by more than 100% (Manjunath et al., 2025; Panwar, Ravishankar, et al., 2021; Ramana et al., 2024). For example, as Panwar illustrates, in the alluvial plains of Bihar, the mean REY increased from an average of 8.7 to 31.3 tonnes/year between 2012–13 and 2017–18. In comparison, in the central plateau zone of Jharkhand, the average REY rose from 7.6 to 36 tonnes/year during the same period (Panwar, Ravishankar, et al., 2021: pp. S24–S25).

This positive trend observed in other agricultural practices is not seen in the case of ZBNF, as its yields do not compare favourably to those of conventional farming methods. However, these results do improve slightly with the continuous application of farmyard manure (ICAR-CRIDA, 2020: pp. 57–58). These findings support the conclusions reached by Galab et al. (2020) in their study of Andhra Pradesh, as well as the IIFSR study on natural farming conducted in 2020–21 across different

agro-climatic zones (Das et al., 2024). This pattern suggests that the IFS may have the potential to stabilize, and possibly significantly enhance, overall productivity for marginal and small farms.

3. *Economic impact on costs, income, and employment*: As mentioned in the previous section, agrarian distress resulting from conventional farming practices and neoliberal policies has caused rising input costs and declining income for farmers. This distress has also led to job losses, contributing to the tragic incidence of suicides among workers and farmers. In this context, we will examine the impact of IFS and their alternatives in terms of three aspects: (a) the reduction of overall costs, including expenses for hired labour and market inputs, (b) the net returns or income generated for every rupee spent, and (c) labour and employment opportunities.
   (a) *Reduction in paid-up costs of inputs:* As previously mentioned, the crisis in conventional farming emerged due to the withdrawal of state support and the rising cost of production (Prasad et al., 2023; Srivastava et al., 2017). This problem was addressed by both ZBNF and IFS by implementing interventions aimed at reducing input costs. For ZBNF, the cost of production for paddy and sugarcane in Andhra Pradesh during the 2019–20 season was only 15% lower than that of conventional farming. This was largely because most farmers did not have the indigenous breed of cows needed to produce *jeevanmithra* on their farms. In contrast, farmers in Karnataka, who were able to make *jeevanmithra* and *beejamithra* on their farms, managed to reduce their costs by 25% in paddy, 45% in sugarcane, and 26% in finger millet (ICAR-CRIDA, 2020: pp. 63–64). This conclusion is further supported by other studies conducted in Andhra Pradesh, which has the longest experience with ZBNF (Galab et al., 2020; Reddy et al., 2019).

   Thus, it is evident that the ZBNF only makes a significant difference to the input costs of the farmers if the inputs can be generated within the farm. The ability of farmers to reduce their costs largely depends on their resource situation before adopting ZBNF. This limitation is even recognized by the proponents of ZBNF, who have begun to advocate for intensifying NF models in states like Telangana, suggesting that it should be combined with pre-monsoon sowing in dry regions (Galab et al., 2024).

   In comparison, the IFS is not designed as a one-size-fits-all production system that relies on a single method to address all farmers' challenges. Instead, it aims to reduce costs by introducing scientifically informed, location-specific, multi-tiered cropping systems that improve both income and soil health. According to the manual on key indicators (Prusty et al., 2021: pp. 6–7), crop cultivation is just one significant aspect of the IFS; the total cost of an IFS strategy is calculated by considering the sum of all paid and imputed costs of its components. The main input costs (excluding labour) consist of purchased inputs from the market and the imputed value of recycled inputs, which is calculated based on current market prices (AICRP-IFS., 2021). The value of recycled inputs represents savings, indi-

cating the total reduction in paid input costs for production at specific sites. In this context, the value of recycled inputs illustrates how market dependence has decreased for small and marginal producers within the IFS.

Analyzing the average zone-wise data from 2012–18 to 2022–23, we see from Table 2.4 of the Appendix that almost all zones have seen a positive growth in the value of recycled inputs. In the foundational phase from 2012–13 to 2017–18, the average reduction in market dependence for inputs varied from approximately 33 to 38% of the total cost in the eastern Gangetic plains and the western coastal plains and hills. In contrast, this reduction ranged from 15 to 16% of the total cost in the Gujarat plains and hills, as well as in the eastern hill region. Overall, the values remained within the range of 20–28%. Thereafter, we observe incremental changes, with all zones achieving positive averages ranging between 20 and 27% from 2018–19 to 2022–23. The only exception is the eastern hills region, which recorded an average value of less than 10%. This indicates that the IFS has the potential to decrease the dependence on market-based inputs through appropriate scientific interventions (Gill et al., 2009; Manjunath et al., 2017; Panwar et al., 2018).

(b) *Farmers' income and net returns*: The previous section has highlighted a sharp decline in the share of income from crop cultivation within the total household income of small and marginal farmers since the early 2000s. This trend indicates that high external input-based agriculture has become unviable for these farmers, necessitating urgent remedial action. In light of this situation, one of the main objectives of both ZNBF and IFS is to suggest sustainable livelihood strategies. The ZBNF approach aims to make farms self-sufficient and efficient, while the IFS focuses on building synergies between different on-farm and non-farm activities to ensure higher incomes.

Studies on ZBNF do not provide precise estimates of the rates of return, but they indicate that the improved quality of the crop leads to better pricing and, therefore, higher returns. For example, in Karnataka, the price of one quintal of paddy produced through natural farming was 150% higher than that produced through non-NF methods. In Maharashtra, these returns were about 15% higher for NF crops than non-NF crops (ICAR-CRIDA, 2020: pp. 61–62). However, later studies have produced more contentious results. For example, a study sponsored by NABARD ICRIER expresses scepticism about the sustainability of the gains from ZBNF (Das et al., 2024). Although Galab et al. (2024) contest this viewpoint, it is well recognized that economic sustainability under ZBNF can only be achieved if natural farming is complemented by intensifying pre-monsoon dryland sowing. Thus, ZBNF alone may not provide year-round income, unless it is supported by other strategies and alternative sustainable farming methods. The study indicates that for ZBNF to attain economic sustainability, it may need to shift away from traditional farming methods and incorporate greater scientific interventions (Galab et al., 2024).

The methods for computing returns under the IFS differ from those of ZBNF. The IFS strategy views the farm as part of a diversified livelihood system that contributes to overall yield and income (Prusty et al., 2021). The total income of a farmer is derived from the returns of multiple complementary interventions, which vary based on the resource base and available materials in different agro-ecological zones (Panwar, Ravishankar, et al., 2021). Average rates of returns in different agro-climatic zones for the period from 2012–13 to 2012–23 are presented in Tables 2.5 and 2.6 of the Appendix.

Table 2.5 presents estimates based solely on paid-out costs, while Table 2.6 incorporates the imputed costs of family labour into its calculations. Both tables show that between 2012–13 and 2017–18, the net returns per INR spent from different models of IFS ranged between 0.56 and 0.86 in ten zones. In two zones, the net returns were above 1.24, while in one zone, it was as low as 0.36. Between 2018 and 2023, these models generated a net return of between 1.12 and 1.71 for every INR spent across all zones, except for the western coastal plains and hills. This trend continues even when the imputed family labour costs are factored into the calculations, as shown in Table 2.6. During this period, the average net return was 1.0–1.24 for every INR spent, while in three zones, the average ranged from 0.46 to 0.76. In all the cases, the IFS models demonstrate positive trends in their profitability.

The trends outlined above are supported by data from different site-specific studies, which show that the returns from IFS are considerably higher than those from conventional farming systems. For example, a study focusing on marginal farmers with land sizes between 0.33 and 0.91 ha, conducted across eight different agro-climatic zones, found that farmers' incomes could increase by approximately 49–136% after implementing IFS models. When comparing these figures to conventional agriculture, the increased income in urban regions ranges from 49 to 65%, while in rural areas, the increase can vary between 65 and 136% (Raju et al., 2024: p. 106). In another study conducted in Telangana over an 11-year period (from 2011 to 2016 and 2017 to 2022) indicates that IFS can increase farmers' profits by 265% compared to traditional single-crop conventional farming methods. This significant increase is primarily due to an average savings of 28% through the use of recycled inputs, as well as the stability of incomes provided by integrating livestock and poultry with cropping systems (Ramana et al., 2024). Overall, studies indicate that IFS models have a greater capacity to generate sustainable income throughout the year and increase income from agricultural activities.

(c) *Labour and employment:* As we have discussed earlier, a major portion of the household income for marginal and small farmers comes from wage labour, with participation in the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) playing an important role. However, this wage labour does not guarantee year-round employment for all family members or the landless labourers in the vicinity. Both ZBNF and

IFS aim to address the issue of insufficient employment within the agricultural system.

The ZBNF follows the family farm model, but there is little information available regarding employment days created in different zones. One survey comparing ZBNF and non-ZBNF farms reveals that on non-ZBNF farms, men contributed a total of 110 h of labour, while women contributed 530 h within the family. In contrast, ZBNF farms generated 60 h of labour for men and 800 h of labour for women. Additionally, the hours of bullock labour generated were recorded as 40 h for non-ZBNF compared to only 10 h for ZBNF farms (Abrol, 2023; CSTEP, 2019: p. 21). The findings indicate that a ZBNF system can increase the workload of women workers within the family, thereby strengthening the traditional division of labour. Further, as Abrol (2023) argues, this model of family farming lacks the capacity to create jobs for landless agricultural workers. A study sponsored by NABARD-ICRIER further reveals that ZBNF generates only 15 additional person-days of work compared to conventional farming methods. The report emphasizes the need for more studies on labour relations within ZBNF systems (Das et al., 2024: p. 41). The cost implications of scaling up ZBNF are closely tied to labour. According to the ICAR-CRIDA report, ZBNF may be viable for small farmers with one or two family members available to work on the farm. However, it may become unviable if they need to hire labour from outside. The report indicates that the unit cost of ZBNF does not support the employment of hired labour (ICAR-CRIDA, 2020: p. 79). This analysis indicates that ZBNF may not be particularly favourable for landless workers.

Similar to the ZBNF, the IFS is also a labour-intensive farming system. However, the IFS may have a greater capacity to create employment opportunities for landless workers than ZBNF. Table 2.7 in the Appendix indicates that the share of the average total cost of labour (comprising both hired labour and the imputed cost of family labour) was more than 30% in all zones except for one during the period between 2018–19 and 2022–23. In the erstwhile Green Revolution areas of the trans-Gangetic plains of Haryana and Punjab, the share of average labour cost was 23%. In the eastern and central plateau and hills, the share of labour costs was approximately 50–55%. In at least four other zones, this share ranged between 44 and 48%. The conversion of this labour cost into person-days of work is depicted in Table 2.8 of the Appendix. The table shows that between 2012–13 and 2017–18, the average number of employment days created per person across various zones was 491 days. Out of 13 zones, six zones managed to create 365 days of work per year. The zonal average number of labour days ranged between 274 and 605 annually. In contrast, between 2018–19 and 2022–23, the average number of employment days created per person was 398 days across zones, with eight zones exceeding 365 days of work. During this period, the zonal averages ranged from 256 to 552 person-days of employment per year.

Though there are no exact figures for the exact value of family labour, we have calculated the imputed cost of family labour as a proportion of total labour costs between 2018–19 and 2022–23, which is presented in Table 2.9 of the Appendix.

The table shows that, on average, the share of the imputed cost of family labour is approximately 47% across all zones during this period. However, there are significant zonal variations. The western and eastern hill regions, as well as the lower and upper Gangetic plains, exhibit a high proportion of family labour costs, ranging from 52 to 74%. In contrast, zones such as the Gujarat plateau and the central and western plateau show a much lower proportion of family labour, ranging from 17 to 24%. In the case of Green Revolution in the trans-Gangetic plains, this proportion is about 35%. In other zones, the percentage of family labour typically falls in the range of 40–45%. This data can be utilized to estimate the total number of average labour days contributed by family labour from 2018 to 2023, as presented in Table 2.10 of the Appendix. The table indicates that, on average, family labour may be employed for about 193 days per year on a hectare of land, while hired labour typically accounts for around 220 days of employment. In some zones, such as the eastern hill region, family labour may be deployed for up to 320 days out of an average total of 444 days of employment created. However, even in this zone, hired labour typically accounts for around 120 days of work. In contrast, in central plateau hills, where family labour is deployed for an average of about 134 days, hired wage employment can reach approximately 400 days or more.

Of course, the figures provided are projections derived from the data in the AICRP-IFS reports. Hence, we should consider them as indications of the potential that IFS models hold for generating both paid and unpaid family labour. It would not be inaccurate to suggest that IFS models can create a significant number of person-days of work for hired labour, despite their substantial dependence on family labour. This conclusion is further supported by studies that use family labour as a proxy to measure the increased participation of women in IFS (Verma et al., 2020). However, many studies have shown that an increased dependence on family labour is seen as a "saving" for farming households (Ramana et al., 2024; Reddy et al., 2019; Verma et al., 2020). This literature indicates that more research is needed to fully understand the impact of IFS and ZBNF on both hired and family labour.

The indicative comparison of the overall ecological and economic impact of the IFS and ZBNF focuses on key indicators that can help us identify which of these models has the potential to address the crisis of social reproduction confronting the semi-proletarianized peasantry today. Our socio-technical studies and preliminary data mapping have highlighted several points for further consideration, which we will elaborate on in our concluding remarks.

## 2.5 Concluding Remarks

This chapter has explored the potential of sustainable agriculture alternatives, such as ZBNF and IFS, to address the challenges faced by a semi-proletarianized peasantry in the current neoliberal times. It has been shown that though the principles underpinning these models are akin to agroecological practices promoted by the FAO, the perspective presented by them has a long contemporary history.

Furthermore, the impact and implications of these practices are relatively marginal in relation to India's overall response to the Sustainable Development Goals Agenda 2030.

We have argued that state-driven neoliberal policy reforms have failed to address the persistent agrarian crisis resulting from the long-term consequences of high external input-based conventional agriculture. This situation has exacerbated the crisis of social reproduction, as reflected by rising production costs, declining incomes, and a lack of gainful employment.

However, these aspects are just the surface of a deeper structural crisis caused by two interrelated factors: (a) the increasing dependence of marginal and small-scale peasants on corporate-dominated markets, which has emerged due to market deregulation and decreasing state investments; and (b) the strong interlinkage between depleting productive relations (as reflected in climate and ecological crisis), and the struggle for survival faced by the majority of rural peasants and workers. Hence, it is essential to ensure some selective delinking of farming systems from the corporate agribusiness-controlled markets. At the same time, we need to restore the ecological foundation by creating synergies between environmental and economic strategies.

Our analysis has revealed some indicative trends worth exploring further in the future. First, it seems that the IFS may offer better synergies between ecological and economic processes, which could help lower farmers' dependence on market fluctuations. However, both systems are vulnerable to market changes, which could only be countered through state support, such as minimum support prices or the reversal of market deregulation. Second, IFS systems appear to provide higher and more stable net returns in comparison to ZBNF or conventional farming methods. This reflects its ability to adapt to local conditions and foster ecological synergies. Additionally, IFS models seem more effective in generating employment opportunities for landless agricultural workers. However, achieving this may require state subsidies for labour deployment to enhance the employment-generation capability of IFS.

Fourth, though family labour contributes significantly to ZBNF and IFS, more effort is needed to understand how the increasing burden of work affects women's lives and working conditions. In fact, improving public infrastructure and recognizing women as farmers may be essential for the IFS to provide adequate support. Lastly, the ZBNF has been implemented in a mission mode with substantial state subsidies at both the state and central levels. However, despite this support, its ability to scale up and create long-term sustainable solutions remains limited. Further, it is focused on capturing a niche elite market for organic goods, which is also driven by corporate interests (Abrol, 2023), leading to higher net returns. In contrast, the IFS model has been implemented by the ICAR through its projects and funds, but it has the potential for broader impact. One might wonder whether implementing it in a mission mode, with state budgetary support, would enable it to become a sustainable alternative for resolving the challenges faced by the semi-proletariat in neoliberal times.

# Appendix

**Table 2.1** Improvement in organic carbon

| Zone | 2019–20 | 2020–21 | 2021–22 | 2022–23 |
|---|---|---|---|---|
| Western Himalayan Region | 21.90 | 63.80 | 38.40 | 33.20 |
| Eastern Himalayan Region | 22.70 | 31.00 | 32.70 | 43.00 |
| Trans Gangetic Plains | 19.20 | NA | NA | NA |
| Upper Gangetic Plains | 20.50 | 14.00 | 13.80 | 15.00 |
| Middle Gangetic Plains | 12.80 | 12.70 | 6.90 | 9.20 |
| Lower Gangetic Plains | 5.88 | 5.90 | NA | NA |
| Eastern Plateau and Hills | 26.30 | 11.10 | 2.40 | 6.20 |
| Central Plateau and Hills | 3.30 | 8.30 | 3.60 | 18.00 |
| Western Plateau and Hills | 8.37 | 11.00 | 14.00 | 12.90 |
| Southern Plateau and Hills | 42.20 | 47.80 | 19.90 | 22.50 |
| East Coast Plains and Hills | 10.70 | 12.30 | 10.30 | 23.00 |
| West Coast Plains and Hills | 0.80 | 49.40 | 55.40 | 55.90 |
| Gujarat Plains and Hills | 6.80 | 4.80 | 15.40 | 43.40 |

Source: AICRP-IFS, Annual Reports of relevant years
Note: Improvement in soil is measured through the increasing percentage of organic carbon content. This is calculated measuring organic carbon content in the base year (2017–18) and subtracting it from the organic content in the current years

**Table 2.2** Net GHG emissions measuring capacity for climate change mitigation

| Zone | 2019–20 | 2020–21 | 2021–22 | 2022–23 |
|---|---|---|---|---|
| Western Himalayan Region | –6603.0 | –7049.0 | –7655.0 | –8066.0 |
| Eastern Himalayan Region | NA | NA | NA | NA |
| Trans Gangetic Plains | –6055.0 | –5451.0 | –2173.0 | –3326.7 |
| Upper Gangetic Plains | –23,038.0 | –28,392.0 | –33,144.0 | –38,284.3 |
| Middle Gangetic Plains | –1446.5 | –1090.0 | –1312.0 | –2455.6 |
| Lower Gangetic Plains | –3248.3 | –3012.0 | –3171.0 | –4797.7 |
| Eastern Plateau and Hills | –8765.0 | –13,176.0 | –647.1 | –12.4 |
| Central Plateau and Hills | 61.9 | 159.2 | –279.0 | –5421.4 |
| Western Plateau and Hills | –2450.0 | –8947.0 | –448.5 | –8291.5 |
| Southern Plateau and Hills | –3958.0 | –6766.0 | –2122.9 | –7094.3 |
| East Coast Plains and Hills | –869.4 | –773.4 | –889.6 | –4098.8 |
| West Coast Plains and Hills | –14,066.0 | –14,386.0 | –7178.9 | –18,363.0 |
| Gujarat Plains and Hills | NA | NA | NA | NA |

Source: AICRP-IFS, Annual Reports of relevant years
Note: Net GHG Emissions are measured by subtracting the GHG emissions from various components of IFS from Carbon Sink and GHG Emissions in the base year, 2017–18

**Table 2.3** Rice equivalent yield in site (tonne/ha)

| Zone | Average area (ha) | Average 2012–18 | 2019–20 | 2020–21 | 2021–22 | 2022–23 |
|---|---|---|---|---|---|---|
| Western Himalayan Region | 1.00 | 23.00 | 24.90 | 22.39 | 29.15 | 33.47 |
| Eastern Himalayan Region | 1.00 | 25.00 | 29.10 | 28.50 | 29.57 | 28.05 |
| Trans Gangetic Plains | 1.00 | 24.50 | 33.50 | 40.65 | 41.00 | 36.79 |
| Upper Gangetic Plains | 0.86 | 15.00 | 21.00 | 21.00 | 28.89 | 19.73 |
| Middle Gangetic Plains | 0.84 | 20.00 | 28.70 | 29.20 | 28.32 | 27.09 |
| Lower Gangetic Plains | 0.66 | 32.40 | 8.90 | 7.75 | 10.24 | 11.36 |
| Eastern Plateau and Hills | 0.80 | 11.00 | 23.10 | 24.94 | 16.70 | 16.32 |
| Central Plateau and Hills | 0.96 | 12.00 | 36.30 | 27.20 | 23.02 | 24.66 |
| Western Plateau and Hills | 1.00 | 14.00 | 35.00 | 22.74 | 33.51 | 34.15 |
| Southern Plateau and Hills | 0.92 | 18.50 | 28.20 | 20.90 | 25.96 | 25.32 |
| East Coast Plains and Hills | 1.00 | 19.00 | 28.60 | 27.76 | 31.29 | 33.27 |
| West Coast Plains and Hills | 1.00 | 24.00 | 13.00 | 13.00 | 16.92 | 19.74 |
| Gujarat Plains and Hills | 1.00 | 18.00 | 23.00 | 5.80 | 22.52 | 21.55 |

Source: AICRP-IFS, Annual Reports of relevant years
Note: REY for 2018–19 is not given in the AICRP Report
Note on decline of mean yield in EPH: In 2021–22, one more site was added with poultry and horticulture as the basis of IFS. The REY conversion showed that the mean yield had come down because one site, Chiplima, was only operational for the first 2 years. Since the REY of each site is not available in the AICRP report, the decline cannot be compared with earlier years
Notes on decline of mean yield in CPH: In 2021–22 two more sites were added with poultry and horticulture as basis of IFS. The REY conversion showed that mean yield had come down because two sites. Kota and Rewa were only operational for the first 2 years. Since REY of each site is not available in AICRP report the decline cannot be compared with earlier years
Note on Errors in Comparison: These figures are taken straight from the Annual Report of the AICRP for different years, and the highlighted data shows deviations from the overall trend. Since the reports present processed data, averages cannot be cross-checked because site-level data is unavailable for some parameters. Hence, it is better to ignore these figures in the analysis. Further, since REY is calculated based on market prices of different products, it is necessary to factor market fluctuations into the analysis

**Table 2.4** Percentage saving through recycling of produce

| Zone | Average 2012–18 | 2018–19 | 2019–20 | 2020–21 | 2021–22 | 2022–23 | Average 2012–23 |
|---|---|---|---|---|---|---|---|
| Western Himalayan Region | 20.00 | 30.24 | 10.95 | 18.12 | 18.96 | 17.96 | 19.25 |
| Eastern Himalayan Region | 16.00 | 11.38 | 9.35 | 9.09 | 10.14 | 8.19 | 9.63 |
| Trans Gangetic Plains | 19.00 | 12.54 | 8.36 | 7.52 | 12.78 | 12.81 | 10.80 |
| Upper Gangetic Plains | 33.00 | 14.00 | 14.72 | 8.70 | 21.10 | 30.93 | 17.89 |
| Middle Gangetic Plains | 28.00 | 27.48 | 16.16 | 16.16 | 14.44 | 12.80 | 17.41 |
| Lower Gangetic Plains | 25.80 | NEG | 20.24 | 19.69 | 18.08 | 15.52 | 18.39 |
| Eastern Plateau and Hills | 28.00 | 17.22 | 16.82 | 21.22 | 21.46 | 12.30 | 17.81 |

(continued)

**Table 2.4** (continued)

| Zone | Average 2012–18 | 2018–19 | 2019–20 | 2020–21 | 2021–22 | 2022–23 | Average 2012–23 |
|---|---|---|---|---|---|---|---|
| Central Plateau and Hills | 27.00 | 18.56 | 7.41 | 12.19 | 17.77 | 12.35 | 13.65 |
| Western Plateau and Hills | 21.50 | 11.09 | 8.41 | 9.54 | 10.73 | 11.60 | 10.27 |
| Southern Plateau and Hills | 20.00 | 16.54 | 16.25 | 15.62 | 20.44 | 22.37 | 18.24 |
| East Coast Plains and Hills | 21.25 | 12.99 | 10.86 | 12.98 | 12.00 | 10.72 | 11.91 |
| West Coast Plains and Hills | 38.33 | 13.82 | 14.55 | 17.58 | 17.03 | 17.17 | 16.03 |
| Gujarat Plains and Hills | 15.50 | 17.06 | 14.71 | 16.00 | 10 | 12.83 | 13.33 |

Source: AICRP-IFS, Annual Reports of relevant years
Note: Percentages represent the proportion of the input costs saved through recycling

**Table 2.5** Rate of net return (excluding cost of family labour)

| Zone | Average 2012–18 | 2018–19 | 2019–20 | 2020–21 | 2021–22 | 2022–23 | Average 2018–23 |
|---|---|---|---|---|---|---|---|
| Western Himalayan Region | 0.80 | 0.62 | 1.71 | 1.40 | 1.18 | 1.19 | 1.22 |
| Eastern Himalayan Region | 0.80 | 1.18 | 1.74 | 1.79 | 1.90 | 1.96 | 1.71 |
| Trans Gangetic Plains | 1.14 | 1.97 | 1.81 | 1.60 | 1.29 | 1.06 | 1.55 |
| Upper Gangetic Plains | 0.57 | 0.85 | 1.42 | 1.59 | 1.51 | 0.65 | 1.21 |
| Middle Gangetic Plains | 0.81 | 0.95 | 1.59 | 1.58 | 1.48 | 0.96 | 1.31 |
| Lower Gangetic Plains | 0.73 | NEG | 1.68 | 1.24 | 1.19 | 1.37 | 1.37 |
| Eastern Plateau and Hills | 0.63 | 0.73 | 1.85 | 1.73 | 1.32 | 0.95 | 1.32 |
| Central Plateau and Hills | 0.74 | 0.99 | 1.85 | 1.49 | 1.33 | 0.99 | 1.33 |
| Western Plateau and Hills | 0.86 | 0.88 | 2.23 | 1.69 | 1.55 | 1.43 | 1.56 |
| Southern Plateau and Hills | 0.52 | 1.53 | 1.25 | 1.60 | 1.64 | 1.15 | 1.43 |
| East Coast Plains and Hills | 2.04 | 0.79 | 1.00 | 1.33 | 1.37 | 1.32 | 1.16 |
| West Coast Plains and Hills | 0.96 | 0.50 | 0.87 | 0.97 | 0.73 | 0.64 | 0.74 |
| Gujarat Plains and Hills | 0.36 | 0.56 | 1.63 | 1.24 | 1.04 | 1.10 | 1.12 |

Source: AICRP-IFS, annual reports of relevant years
Note: Net rate of return (excluding imputed cost of family labour) = net returns (gross income – paid up cost)/total cost

**Table 2.6** Rate of net return (including cost of family labour)

| Zone | 2018–19 | 2019–20 | 2020–21 | 2021–22 | 2022–23 | Average 2018–23 |
|---|---|---|---|---|---|---|
| Western Himalayan Region | 0.49 | 1.57 | 1.27 | 0.69 | 1.04 | 1.01 |
| Eastern Himalayan Region | 0.93 | 1.50 | 1.77 | 1.51 | 1.51 | 1.43 |
| Trans Gangetic Plains | 1.79 | 1.65 | 1.48 | 0.72 | 1.02 | 1.41 |
| Upper Gangetic Plains | 0.57 | 1.27 | 1.42 | 1.04 | 0.54 | 1.07 |
| Middle Gangetic Plains | 0.64 | 1.35 | 1.35 | 0.93 | 0.85 | 1.07 |
| Lower Gangetic Plains | NEG | 1.59 | 1.05 | 0.83 | 1.01 | 1.16 |
| Eastern Plateau and Hills | 0.45 | 1.85 | 1.66 | 1.01 | 0.73 | 1.24 |
| Central Plateau and Hills | 0.56 | 1.14 | 1.03 | 0.75 | 0.81 | 0.87 |
| Western Plateau and Hills | 0.62 | 1.93 | 1.39 | 0.76 | 0.13 | 1.18 |
| Southern Plateau and Hills | 1.24 | 1.07 | 1.46 | 1.33 | 0.89 | 1.27 |
| East Coast Plains and Hills | 0.54 | 0.79 | 1.06 | 0.65 | 1.06 | 0.76 |
| West Coast Plains and Hills | 0.30 | 0.55 | 0.89 | 0.10 | 0.50 | 0.46 |
| Gujarat Plains and Hills | 0.35 | 1.26 | 1.06 | 0.15 | 1.10 | 0.71 |

Source: AICRP-IFS, annual reports of relevant years
Note: Net rate of return (including imputed cost of family labour) = net returns (gross income – (paid up + imputed cost of family labour))/total cost

**Table 2.7** Labour intensity of IFS

| Zone | 2018–19 | 2019–20 | 2020–21 | 2021–22 | 2022–23 | Average 2018–23 |
|---|---|---|---|---|---|---|
| Western Himalayan Region | 29.96 | 38.00 | 29.00 | 30.00 | 29.00 | 31.19 |
| Eastern Himalayan Region | 57.30 | 40.00 | 40.00 | 40.00 | 51.00 | 45.66 |
| Trans Gangetic Plains | 35.06 | 22.00 | 17.00 | 27.00 | 14.00 | 23.01 |
| Upper Gangetic Plains | 58.90 | 36.00 | 43.00 | 44.00 | 40.00 | 44.38 |
| Middle Gangetic Plains | 69.18 | 43.00 | 42.00 | 42.00 | 45.00 | 48.24 |
| Lower Gangetic Plains | 38.00 | 48.00 | 59.00 | 36.00 | 56.00 | 47.40 |
| Eastern Plateau and Hills | 59.37 | 49.00 | 46.00 | 46.00 | 52.00 | 50.47 |
| Central Plateau and Hills | 56.49 | 68.00 | 56.00 | 47.00 | 51.00 | 55.70 |
| Western Plateau and Hills | 51.77 | 52.00 | 41.00 | 38.00 | 41.00 | 44.75 |
| Southern Plateau and Hills | 52.49 | 46.00 | 40.00 | 46.00 | 46.00 | 46.10 |
| East Coast Plains and Hills | 50.84 | 26.00 | 34.00 | 31.00 | 32.00 | 34.77 |
| West Coast Plains and Hills | 48.73 | 37.00 | 31.00 | 35.00 | 30.00 | 36.35 |
| Gujarat Plains and Hills | 43.51 | 37.00 | 30.00 | 29.00 | 34.00 | 34.70 |
| Annual averages | 50.12 | 41.69 | 39.08 | 37.77 | 40.08 | 41.75 |

Source: AICRP-IFS, annual reports of relevant years
Note: Labour intensity is the share of total labour cost (hired + imputed cost of family Labour) in the total cost of production

**Table 2.8** Average total person days of employment created per zone

| Zone | Average 2012–18 | 2018–19 | 2019–20 | 2020–21 | 2021–22 | 2022–23 | Average 2018–23 |
|---|---|---|---|---|---|---|---|
| Western Himalayan Region | 502 | 404 | 457 | 410 | 393 | 392 | 411 |
| Eastern Himalayan Region | 374 | 414 | 462 | 464 | 442 | 441 | 444 |
| Trans Gangetic Plains | 274 | 315 | 498 | 280 | 333 | 351 | 355 |
| Upper Gangetic Plains | 437 | 363 | 573 | 572 | 630 | 656 | 559 |
| Middle Gangetic Plains | 489 | 397 | 449 | 375 | 443 | 381 | 409 |
| Lower Gangetic Plains | 605 | 232 | 252 | 328 | 317 | 329 | 292 |
| Eastern Plateau and Hills | 295 | 303 | 253 | 399 | 309 | 330 | 319 |
| Central Plateau and Hills | 262 | 268 | 789 | 639 | 556 | 501 | 551 |
| Western Plateau and Hills | 285 | 562 | 608 | 526 | 471 | 476 | 529 |
| Southern Plateau and Hills | 369 | 593 | 504 | 502 | 738 | 422 | 552 |
| East Coast Plains and Hills | 516 | 449 | 414 | 388 | 395 | 403 | 410 |
| West Coast Plains and Hills | 555 | 369 | 280 | 262 | 268 | 272 | 290 |
| Gujarat Plains and Hills | 439 | 308 | 238 | 243 | 256 | 226 | 254 |

Source: AICRP-IFS, annual reports of relevant years
Note: Person days of employment are calculated by adding the person days (paid and unpaid) created by each component of IFS, annually

**Table 2.9** Family labour as a percentage of total average labour cost

| Zone | 2018–19 | 2019–20 | 2020–21 | 2021–22 | 2022–23 | Average 2018–23 |
|---|---|---|---|---|---|---|
| Western Himalayan Region | 45 | 63 | 69 | 67 | 52 | 59 |
| Eastern Himalayan Region | 44 | 40 | 95 | 95 | 86 | 72 |
| Trans Gangetic Plains | 51 | 23 | 0 | 74 | 29 | 35 |
| Upper Gangetic Plains | 47 | 75 | 74 | 36 | 25 | 52 |
| Middle Gangetic Plains | 46 | 47 | 45 | 48 | 22 | 41 |
| Lower Gangetic Plains | 0 | 81 | 66 | 100 | 64 | 62 |
| Eastern Plateau and Hills | 46 | 100 | 85 | 78 | 42 | 70 |
| Central Plateau and Hills | 35 | 0 | 20 | 32 | 35 | 24 |
| Western Plateau and Hills | 50 | 42 | 32 | 0 | 29 | 31 |
| Southern Plateau and Hills | 55 | 61 | 73 | 67 | 63 | 64 |
| East Coast Plains and Hills | 50 | 19 | 18 | 19 | 81 | 38 |
| West Coast Plains and Hills | 41 | 14 | 68 | 49 | 47 | 43 |
| Gujarat Plains and Hills | 50 | 0 | 33 | 0 | 0 | 17 |
| Annual averages | 43 | 43 | 52 | 51 | 44 | 47 |

Source: AICRP-IFS, annual reports of relevant years
Note: The share of family labour in total labour cost = imputed cost of family labour/total labour cost (hired + imputed cost of family labour) × 100

**Table 2.10** Projected ratio of person days of family labour vis-à-vis hired labour

| Zone | Average days of employment created | Proportion of family labour | Project family labour days | Projected days created for hired labour |
|---|---|---|---|---|
| Western Himalayan Region | 411 | 59 | 243 | 168 |
| Eastern Himalayan Region | 444 | 72 | 320 | 124 |
| Trans Gangetic Plains | 355 | 35 | 125 | 230 |
| Upper Gangetic Plains | 559 | 52 | 289 | 270 |
| Middle Gangetic Plains | 409 | 41 | 169 | 239 |
| Lower Gangetic Plains | 292 | 62 | 182 | 110 |
| Eastern Plateau and Hills | 319 | 70 | 224 | 95 |
| Central Plateau and Hills | 551 | 24 | 134 | 417 |
| Western Plateau and Hills | 529 | 31 | 162 | 367 |
| Southern Plateau and Hills | 552 | 64 | 352 | 199 |
| East Coast Plains and Hills | 410 | 38 | 154 | 256 |
| West Coast Plains and Hills | 290 | 43 | 126 | 164 |
| Gujarat Plains and Hills | 254 | 17 | 42 | 212 |
| Annual averages | 413 | 47 | 193 | 220 |

Source: AICRP-IFS, annual reports of relevant years
Note: This table is derived from the calculations in Tables 2.8 and 2.9. It represents the share of family labour in the total labour days generated through IFS strategies

## References

Abrol, D. (1983, October). American involvement in agricultural research. *Social Scientist, 11*(10), 8–26.

Abrol, D. (2020). Concentration in global seed & agro-chemical industry: implications for Indian agriculture. In *Corporate concentration in food and agriculture.* Focus of the Global South and Rosa Luxemburg Foundation.

Abrol, D. (2023). Agroecology and agrarian transitions: The current debate in India. *Agrarian South: Journal of Political Economy, 12*(2), 161–186.

AICPR-IFS. (2015). *Annual report, 2014–15*. ICAR-Indian Institute of Farm Systems Research.

AICRP-IFS. (2018). *Annual report, 2017–18*. All India Cooordinated Project on Integrated Farming Systems, IIFSR-ICAR.

AICRP-IFS. (2019). *Annual report, 2018–19*. All India Cooordinated Project on Integrated Farming Systems, IIFSR-ICAR.
AICRP-IFS. (2020). *Annual report, 2019–2020*. All India Cooordinated Project on Integrated Farming Systems, IIFSR-ICAR.
AICRP-IFS. (2021). *Annual Report, 2020-2021*. All India Coordinated Research Project on Integrated Farming Systems—ICAR.
AICRP-IFS. (2022). *Annual report, 2021–2022*. All India Cooordinated Project on Integrated Farming Systems, IIFSR-ICAR.
AICRP-IFS. (2023). *Annual Report, 2022–23*. Indian Institute of Farming Systems Research, Indian Council of Agricultural Research.
Altieri, M. (1995). *Agroecology: The science of sustainable agriculture*. CRC Press.
Bakker, L., van der Werf, W., Wyckhuys, K., & Bianchi, F. (2020). Neonicotinoids in global agriculture: evidence for a new pesticide treadmill? *Ecology and Society*. https://doi.org/10.5751/ES-11814-250326
Bathla, S., Joshi, P., & Kumar, A. (2020). *Agricultural growth and rural poverty reduction in India: Targeting investments and input subsidies*. Springer.
Bhalla, G. (2017). *Indian agriculture since independence*. National Book Trust.
Carson, R. (1962). *Silent spring*. Houghtan Mifflin.
Chakravarty, S. (1987). *Development planning: The Indian experience*. Claredon Press.
Chand, R. (2019, December). *Transforming Indian Agriculture for Challenges in the 21st Century, Presidential Address to 102 Session of Indian Economic Association,* (27–29). Auro University Surat.
Chand, R. (2023). Indian agriculture towards 2030: Need for transformative vision. In R. Chand (Ed.), *Indian agriculture towards 2030: Pathways for enhancing farmers incomes, nutritional security and sustainable food and farm systems*. Niti Aayog, Food and Agriculture Organisation and Springer.
Crosby, A. (1986). *Ecological imperialism: The biological expansion of Europe, 900–1900*. Cambridge University Press.
CSE. (2020). *The state of organic and natural farming in India: Challenges and possibilities*. Centre for Science and Environment.
CSTEP. (2019). *Life cycle assessment of ZBNF and non ZBNF: A case study of Andhra Pradesh*. Centre for the Study of Science, Technology and Policy.
Damodaran, H. (2025, March 5). Why India's Agricultural Trade Surp[us is Shrinking. *Indian Express*.
Das, S., Khurana, M., & Gulati, A. (2024). *Zero budget natural farming: Implications for sustainability, profitability and food security.* National Bank of Agriculture and Rural Development Study No 43 with ICRIER.
Diamond, J. (1999). *Guns, germs and steel: The fates of human societies.* WW Norton
FAO. (2013). *FAO'S work on agroecology: A pathway to acheiving SDGs*. Food and Agriculture Organisation.
FAO. (2015). *Status of world's soil resources*. Food and Agriculture Organisation.
Foster, J. (1999). Marx's concept of metabolic rift. *American Journal of Sociology, 105*(2), 366–405.
Frankel, F. (2015). *India's green revolution: Economic gains and political costs*. Princeton University Press.
Galab, S., Murty, C., & Rao, G. (2024, December 28). Efficacy of natural farming over chemical farming: A case of Andhra Pradesh. *Economic and Political Weekly*, 45–51.
Galab, S., Reddy, P., Raju, S., Ravi, C., & Rajani, A. (2020). *Impact assessment of zero budgeting natural farming in Andhra Pradesh: A comprehensive approach using crop cutting experiments for agricultural year 2018–19*. Centre for Economic and Social Studies.
Gill, M., Singh, J., & Gangwar, K. (2009). Integrated farming systems and agricultural sustainability. *Indian Journal of Agronomy, 54*(2), 128–139.
Gliessman, S. (2015). *Agroecology: The ecology of sustainable food systems*. CRC Press.

Goswami, B., Bezbaruah, M., & Mandal, R. (2018). *Indian agriculture after green revolution: Issues and challenges*. Routledge.

Grove, R. (1995). *Green imperialism: Colonial expansion, tropical isle Edens and the origins of environmentalism, 1600–1900*. Cambridge University Press.

Gulati, A., Roy, R., & Saini, S. (2021). *Revitalising Indian agriculture and boosting farmers' income*. Springer.

Gupta, N., Pradhan, S., Jain, A., & Patel, N. (2021). *Sustainable agriculture in India*. CEEW and The Food and Land Coalition.

Hansen, M. (1988). *Escape from pesticide treadmill: Alternatives to treadmill in developing countries*. Institute for Consumer Policy.

ICAR-CRIDA. (2020). *Adoption of natural farming and its effects on crop yield and farmers' livelihood in India*. ICAR-National Academy for Agricultural Research.

IIFSR. (2015). *Mission 2050*. Indian Institute of Farming Systems Research, Indian Council of Agricultural Research.

Iyengar, S. (2022). Sustainable development goals and Gandhi's thought perspective. In A. Behera & S. Nayak (Eds.), *Gandhi in the twenty first century: Ideas and relevance* (pp. 37–56). Springer.

Jha, P. (2024, February). Growing restiveness of the peasantry in contemporary India. *Agrarian South: Journal of Political Economy*. https://doi.org/10.1177/22779760231226295

Jha, P., & Acharya, N. (2009). Expenditure on the rural economy in India's budgets since the 1950s: An assessment. *Review of Agrarian Studies*. https://doi.org/10.25003/RAS.01.02.0005

Jha, P., & Mishra, P. (2022). Persistent vulnerabilities in the world of work and contemporary capitalism: Some reflections on India. *Indian Journal of Labour Economics, 65*(2), 347–372.

Jha, P., & Prasad, A. (2020). Wages of neoliberalism: Reflections on the world of work in contemporary India. *Brazilian Journal of Social and Labour Economics*, 1–21.

Jha, P., Singh, G., & Sharma, N. (2019). Modern agricultural practices in India: Impacts on occupational safety, health, and environment. In I. C. Scherrer & R. Katja (Eds.), *Occupational safety and health challenges in southern agriculture* (pp. 24–48). Rainer Hampp.

Jha, P., & Yeros, P. (2019). Global agricultural value systems and the south: Some critical issues at the current juncture. *Agrarian South: Journal of Political Economy, 8*(1–2).

Jha, P., Yeros, P., Chambati, W., & Mazwi, F. (2022). *Farming and working under contract: Peasants and workers in global agricultural value systems*. Tulika Books.

Kumar, S., Bhatt, B., Dey, A., & Kumar, U. (2018). Integrated farming system in India: Current status, scope and future prospects in changing agricultural scenario. *Indian Journal of Agricultural Sciences*, 1661–1675.

Kumarappa, J. C. (1951). *Gandhian economic thought*. Sarva Seva Sangh.

Levins, R. (2020). *Talking about trees: Science, ecology and agriculture in Cuba*. Leftword.

Magdoff, F., & Tokar, B. (2010). *Agriculture and food in crisis: Conflict resistance and renewal*. Monthly Review Press.

Manjunath, B., Laxman, R., & Ramesha, G. (2025). Integrated farming systems improves climate resilience and productivity of rainfed mango (*Mangifera indica*) orchards. *Indian Journal of Agronomy, 70*, S112–S116.

Manjunath, B., Paramesh, V., Mahajan, G., Das, B., Reddy, K., Chakurkar, E., & Singh, N. (2017). Sustainability through resource recycling, soil fertility and carbon sequestration from integrated farming in Western Coastal Plains. *The Bioscan*, 1–6.

Mittal, S., Kaur, G., & Vishwakarma, G. (2014). Effects of environmental pesticides on the health of rural communities in the Malwa region of Punjab, India: A review. *Human and Ecological Risk Assessment: An International Journal, 20*, 366–387.

NABARD. (2017). *National rural financial inclusion survey, 2016–17*. National Bank for Agriculture and Rural Development.

NABARD. (2021). *National rural financial inclusion survey, 2020–21*. National Bank for Agriculture and Rural Development.

Narayanan, S. (2003). *Organic farming in India: Relevance, prospects and constraints*. National Bank for Agriculture and Rural Development.

NCRB. (2023). *Accidental deaths and suicides in India, 2022*. National Crime Records Bureau.

NSSO. (2014). *Key indicators of situation assessment of agricultural households in India (January 2013–December 2013).*. National Sample Survey Organisation.

NSSO. (2021). *Situation assessment of agricultural households, land and livestock holdings of households in rural India (January 2019–December 2019).*. National Sample Survey Organisation.

Panwar, A., Prusty, A., Shamim, M., Ravishankar, N., Alam, M., & Singh, R. (2021). Nutrient recycling in integrated farming systems for climate resilience and sustainable income. *Indian Journal of Fertilisers*, 1126–1137.

Panwar, A., Ravishankar, N., Shamim, M., & Prusty, A. (2018). Integrated farming systems: A viable option for doubling incomes of small and marginal farmers. *Bulletin of Soil Science, 32*, 68–88.

Panwar, A., Ravishankar, N., Singh, R., & Prusty, A. (2021). Potential of integrated farming systems for different ecosystems. *Indian Journal of Agronomy, 66*, S15–S32.

Patnaik, P. (1998). Some Indian debates on planning. In T. J. Byres (Ed.), *The Indian economy: Major debates since independence* (pp. 159–192). Oxford University Press.

Patnaik, U. (2024a, May 26). Neoliberalism has increased mass poverty. *Peoples Democracy*.

Patnaik, U. (2024b). The many republics of hunger. *Agrarian South: Journal of Political Economy*. https://doi.org/10.1177/22779760241288014

Prasad, A., Abrol, D., Jha, P., Mathais, T. V., & Herzig, C. (2023). *Impact of corporate integrated farm solutions on small farmers: A case study of Bayer, Karnal, India*. Global Partnership Network Working Paper.

Prusty, A. K., Ravishankar, N., Shamim, M., Raghavendra, k. J., Singh, R., Kashyap, P., Ansari, M. A., & Kumar, S. (2021). *Researchers manual on key performance indicators of integrated farming systems.* All India Coordinated Research Project on Integrated Farming Systems, IIFSR-ICAR.

Raju, A., Ganesh, G., & Kiran, S. (2024). Integrated farming system: A tool to doubling farmer income in the present scenario. In S. Sharma & A. Rawat (Eds.), *Doubling farmer's incomes: Issues, strategies and recommendation* (pp. 97–117). AkiNik.

Ramana, M., Kumari, C., Goverdhan, M., Sridevi, S., Reddy, G., Suresh, K., Chandra, M., Karthik, R., Santhosh Kumar, M., & Ravishankar, N. (2024). Crop + horticulture + livestock IFS model for ensuring food and livelihood security with improving profitability employability and climate resilience: Along teerm study of Telangana. *Economic Development and Sustainability*. https://doi.org/10.1007/s10668-024-04906-w

Reddy, B., Reddy, V., & Mandala, S. (2019). Potential and constraints of zero budgeted natural farming (ZBNF): A case study of Andhra Pradesh. *Journal of Agricultural Economics, 74*(3), 321–333.

Roy, R., & Terway, P. (2024). Rising wage income and role of MGNREGA in agricultural households in India: Evidence from the situation assessment survey. *Indian Journal of Labour Economics, 67*(3), 865–881.

Shiva, V. (2016). *The violence of the green revolution: Third world agriculture, ecology and politics*. University of Kentucky Press.

Srivastava, A., & Kothari, A. (2014). *Churning the earth: The making of global India*. Penguine Random House.

Srivastava, S., Chand, R., & Singh, J. (2017). Changing crop production cost in India: Input prices, substitution and technological effects. *Agricultural Economic Review*, 171–182.

Verma, N., Ravishankar, N., & Panwar, A. (2020). An integrated approach for gender in farming systems: A way forward for transformation and equity. In F. Poulsen (Ed.), *Farmers and farming: Practices, management and challenges* (pp. 101–136). Nova Scientific.

Worster, D. (1977). *Nature's economy: The roots of ecology*. Sierra Club Books.

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# Chapter 3
# Sustainable Soil Management in Tunisia: Exploring Agroecology Initiatives and the Potential for Future Agroecology Transformations

**Ayoub Fouzai, Nora Schütze, Andreas Thiel, Annabelle Buhrow, Ariane Götz, and Ons Kammarti**

**Abstract** In recent years, agroecological farming practices and the broader paradigm of agroecology have emerged as a way to address multiple crises related to food systems, including land degradation and its drivers. Given the significant threats posed by land degradation to countries worldwide, including Tunisia, this study aims to investigate the current status of agroecological initiatives addressing land degradation in the country. Furthermore, we seek to understand the potential for future widespread agroecology transformations and the institutional factors that hinder such transformations.

**Keywords** Tunisia · Agroecology · Transformation · Soil governance · Rainfed agriculture

## 3.1 Introduction

In recent years, agroecology has emerged as a prominent paradigm for shaping agriculture and the food system.[1] This paradigm shift in agriculture and food

[1] This chapter is a revised, updated, and expanded version of a paper previously published as "Soil governance in Tunisia: analyzing the potentials for agroecology transformations" in *Agroecology and Sustainable Food Systems* (Schütze et al., 2025).

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systems encompasses three interconnected dimensions: agronomic practices, scientific orientation, and political movement (Wezel et al., 2009). Agroecology thereby seeks to transform agriculture and the food systems it is embedded in, aligning them with ecological principles to promote sustainability. By doing so, agroecology is considered to be able to address multiple crises, including land degradation and desertification (IPES-Food, 2022). By promoting practices such as reduced tillage, organic manure, cover crops, agroforestry, and intercropping, agroecology can improve soil quality, prevent erosion, and reverse other forms of land degradation (FAO et al., 2020; Liniger et al., 2011). Agroecology goes beyond merely implementing sustainable land management practices; it also considers the systemic drivers of unsustainable practices and aspects of economic and social equity. Thus, agroecology can also help address the underlying challenges and drivers of land degradation, such as farmers being forced to adopt unsustainable practices to sustain their livelihoods.

In Tunisia, the focus of this chapter, national policymakers, such as the Ministry of Agriculture, Water Resources, and Fisheries (MARHP) or the Ministry of Environment, highlight the importance of agroecology in combating land degradation (see MARHP & DGACTA, 2017; Ministère de l'Environement, 2023). International organizations and donors, such as FAO Regional Conference for the Near East (2022) and the European Commission's Directorate-General for Neighbourhood and Enlargement Negotiations (2023), have also emphasized the need to strengthen agroecological practices in the country. Furthermore, the number of externally funded projects related to agroecology has increased in the last decade (see Lestrelin & Jaouadi, 2022). Despite these calls and initiatives, many obstacles remain. Traditional farming practices, such as indigenous water harvesting systems, which align with the principles of agroecological practices—even though not explicitly framed as such—have been abandoned due to colonial and post-independence policies (Jebari et al., 2015). At the same time, many unsustainable farming practices persist (Chebbi et al., 2019), and essential elements of agroecology, such as equitable value chains and smallholder farmer empowerment, are not being adequately addressed. Lastly, agroecology as a movement is also small, even though it has gained some momentum (Goetz et al., 2023). The increasing political importance of agroecology in Tunisia is thus in contrast with the only scattered examples of agroecological farming practices on the ground.

Against this backdrop, this chapter aims to investigate the current status of agroecology in Tunisia, exploring the potential for agroecological transformation as well as the factors hindering such a transformation. Here, transformations are seen as a political processes that challenge the social, political, and economic structures underpinning the current farming and food systems (Béné, 2022). We focus on soil governance as a key example. Soil conservation serves as a vital indicator of agroecological practices because soil is not only a fundamental resource for agricultural

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systems but also a nexus where ecological, social, and economic dimensions intersect. Soil health is central to agroecology, as it directly impacts the productivity, resilience, and sustainability of agricultural systems. Moreover, soil conservation is deeply influenced by governance, land tenure systems, local knowledge systems, and community participation, all of which are core to agroecological transformations. A further reason for highlighting soil governance is that Tunisia faces significant land degradation challenges and is particularly vulnerable in global land degradation assessments due to its arid and semi-arid climate and hilly terrain (Nachtergaele et al., 2010). These land degradation processes lead to a decline in soil health, leading to a significant decline in agricultural productivity, and undermining food security (FAO & ITPS, 2015; World Bank, 2019). Furthermore, erosion and desertification exacerbate the vulnerability of ecosystems, reduce the resilience of plant and animal species, and adversely impact the livelihoods that depend on these ecosystems. At the same time, we acknowledge that focusing on agroecological transformation in the context of soil governance and land degradation does not encompass the full range of agroecological practices, such as pest and disease management. However, we argue that it provides a lens through which we can examine systemic change towards agroecological systems. Our empirical focus will be on three local case studies in Siliana, Kairouan, and Kef governorates.

Conceptually, we analyze Tunisian soil governance through the framework of "domains of agroecology transformations" developed by Anderson et al. (2019, 2021). This framework aims to understand how agroecology spreads beyond its niche and identifies six essential domains that facilitate agroecology transformations, which are characterized as bottom-up processes driven by self-organizing communities. Governance and institutions, understood as formal and informal "rules of the game" (North, 1990)—such as who has access to certain resources and who cannot—can significantly influence these domains as enabling or disabling factors (Anderson et al., 2021). We argue that there is a close nexus between agroecological practices and governance and institutions. These institutions shape people's values, cognition, and preferences, thereby framing and influencing their choices and actions (Vatn, 2005). Effective governance and institutions are prerequisites for the emergence of agroecology, including both agroecological practices and the broader paradigm of agroecology that seeks to transform agriculture and the food system. Although the framework acknowledges the role of governance and institutions (Anderson et al., 2021), it does not always clearly articulate this within each dimension. Therefore, we focus on the impact of institutions and governance across the six domains (see Table 3.1).

The domains of agroecology transformation include several key aspects, with the first being the rights to nature, which encompasses land, water, seeds, and biodiversity. Property rights regimes play a crucial role in this context. According to Anderson et al. (2021), these regimes should ensure equitable access, formally and informally, to land, water, forests, fisheries, seeds, and biodiversity. They must be sensitive to cultural and contextual aspects and support the implementation of traditional management regimes. Moreover, property systems that promote sustainable resource use can be very diverse, involving various combinations of private, common, and public property rights that regulate resource access and usage (Ostrom,

**Table 3.1** Institutional dimensions of Anderson's six domains of transformation

| | |
|---|---|
| Access to land and nature | Do farmers have stable and adequate rights to access and use land, water, and seeds? |
| | Are the rights to access and use land, water, and seeds equally distributed among farmers? |
| Knowledge and culture | Is knowledge of agroecological practices available among farmers? Is traditional and context-specific knowledge by farmers valued? |
| | Do research, extension, and education systems value and support agroecology? |
| | Is information about the performance of the farming sector and its environmental implications available for farmers, consumers, and citizens? |
| Systems of economic exchange | Can farmers and food system actors freely organize their way of farming and food marketing methods? |
| | Do fair and short distribution networks exist that connect consumers and producers at the territorial level? |
| Networks | Do farmers have the means and abilities to organize themselves? |
| | Does the public sector allow and promote self-organization and cooperation between consumers, producers, and civil society? |
| | Do local governments have financial and legal autonomy from the central state to self-organize? |
| Equity | Is gender equality in farming and the broader food systems supported and guaranteed? |
| | Are external dependencies for agricultural inputs low? Are productive conditions fair, and social inequalities along the supply and value chain addressed? |
| Discourse | Does the dominant policy discourse value and promote agroecology and alternative farming practices? |
| | Does the discourse among farmers promote agroecology and alternative farming practices? |

Source: Based on Anderson et al. (2021), Goetz et al. (2023), HLPE (2019)

1990). Additionally, policies and laws regarding land and tenure should be gender-sensitive, ensuring equal access for women, including the right to inherit land (FAO, 2019). Indeed, agroecological transformations, which focus on autonomy and self-determination, must be inclusive and grounded in gender equality.

The second domain focuses on knowledge and culture, focusing on how knowledge is "produced, shared, and mobilized," as well as identifying who is recognized as a legitimate knowledge holder (Anderson et al., 2021: 8). Due to the context-specificity of agroecology (High Level Panel of Experts on Food Security and Nutrition, 2019) as well as of Sustainable Land Management (SLM) (Sanz et al., 2017), agroecological knowledge arguably differs from scientific or policy-related knowledge. It is derived from networks of indigenous peoples and food producers, and is place-based and lived. The transfer and maintenance of such knowledge is vital, which is why research and education systems should value it. We also consider that the availability of information on the economic, environmental, and social performance of the food sector is crucial for actors to self-organize and challenge the current food systems (Goetz et al., 2023).

The third dimension focuses on systems of economic exchange, which relate to the entire value chain. This encompasses how products move from producers to consumers and how producers acquire inputs for their production (Anderson et al., 2019). Governance of property rights serves as the foundation for economic exchange among market participants by defining rules for these exchanges, implementing accountability mechanisms, and monitoring and controlling markets. Important principles in this context include ensuring that farmers and other actors of the food sector have access to markets and a certain degree of autonomy in their market transactions (Dumont et al., 2016; Goetz et al., 2023). Exchange systems should prioritize small quantities, different products, and local diets, and emphasize community networks and traditional exchange systems such as informal markets or barter. Further, markets should facilitate the creation of multiple values and strengthen the connections between producers and consumers through more localized and embedded market structures (Bezner Kerr et al., 2022; Gliessman, 2016).

Networks play a crucial role in the networking of farmers and civil society at different scales. These networks include grassroots actors and federations of farmers' organizations, all of which facilitate knowledge exchange and enhance the agency of farmers (Anderson et al., 2021). By strengthening self-organization and coordination of communities for agroecology, these networks offer alternatives for shaping agricultural and food systems, complementing the important role of the state. Additionally, agroecology networks aim to empower marginalized groups and promote food and social justice, as well as gender equality. Importantly, agroecological development operates within a multi-scalar governance framework, adopting a territorial approach that fosters coordination between local communities and households within a given territory (González de Molina et al., 2019).

The fourth dimension, equity, represents one of the core principles of agroecology (Dumont et al., 2016; Gliessman, 2016). It emphasizes the importance of explicitly addressing power and related inequities, setting agroecology apart from other forms of sustainable agriculture, such as organic farming. Institutions and interrelated governance play a crucial role in promoting equity, as they determine access to resources and shape the decision-making processes. These factors ultimately determine who can accumulate wealth and benefit from public goods such as education or social security services.

The final dimension focuses on discourses, which are the ways in which language is used to shape debates. These discourses can either undermine and delegitimize certain approaches or prioritize others, thereby either supporting or hindering transformations in agroecology (Anderson et al., 2019). Agroecology has been adopted by many international organizations, such as the FAO (Barrios et al., 2020) or the United Nations (2021). However, interpretations of agroecology have increasingly become contested (Pimbert, 2018). Our focus is on how agricultural problems and their underlying causes are framed in policies, as well as how farmers perceive problems related to land degradation and their solutions.

## 3.2 Research Design

### *3.2.1 Methods*

The research design builds on a multi-level analysis at the national, regional, and local levels to examine how existing farming practices and land management policies in Tunisia relate to the six domains of agroecological transformation discussed above. Tunisia was selected due to its identification as one of the most vulnerable countries in global land degradation assessments (Nachtergaele et al., 2010). The rationale for using a multi-level analysis is that Tunisia operates as a centralized state where policies are made at the central level, while it is essential to capture farmers' perspectives at the local level. Our aim is to understand the current status of agroecology and existing initiatives, identify the potential for further agroecology transformation, and recognize the hindering factors to this progress. We use SLM as a proxy for agroecology, although it does not encompass the full range of agroecological practices, especially regarding pest and disease management. However, several farming practices that enhance soil management and fertility—such as reduced tillage, integration of legumes, and the use of organic manure—are relevant for North Africa and can be considered as "practices with agroecological potentials" (Ameur et al., 2020).

At the national level, we reviewed policies and strategies related to the environment, agriculture, land use, and finance. Further, in 2021, we conducted 18 stakeholder interviews with public and private actors from different sectors. This study includes an exploratory case study design focusing on local case studies of rainfed agriculture in three Tunisian governorates: Siliana, Kef, and Kairouan (see Fig. 3.1). Our aim is to understand the barriers hindering farmers from implementing SLM measures. At the local level, we conducted focus group discussions with local administrations and farmers. Participants at both local and regional levels were selected based on pre-existing contacts and snowball sampling. The data was analyzed through qualitative content analysis (Mayring, 2000), using a coding scheme of the six domains of transformations presented in Table 3.1.

### *3.2.2 Case Studies*

Tunisia is severely affected by land degradation, which refers to the reduction or loss of the land's biological or economic productivity and complexity as a result from human activities (Sanz et al., 2017: 18). The country's agricultural sector is significant, with 10.4 million hectares of a total of 16.2 million hectares of surface area used for farming (Chebbi et al., 2019). However, this comes with a significant cost; water erosion, the dominant form of land degradation in the country, affects 3 million hectares. Furthermore, 46% of crops are grown on land with limited fertility, and 1.1 million hectares are cultivated on erosion-prone land (ITES, 2017).




**Fig. 3.1** Administrative map of Tunisia and selected case study regions. Source: Esri, DeLorme, HERE, MapmyIndia. Map was created using ArcGIS Online by Esri. Basemap "Light Gray Canvas Map." Note: This map in this figure was created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright ©Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com

Furthermore, land degradation and water stress, which have significantly risen in the last 20 years, negatively impact each other. Climate change also intensifies problems of land degradation in Tunisia due to increasing temperatures, changing precipitation patterns, and prolonged droughts (Chebbi et al., 2019). Major human-induced causes related to agriculture include overgrazing, unregulated livestock access to public lands, land clearing for cereal cultivation, and farming practices that are not well adapted to local conditions (Chebbi et al., 2019).

This chapter focuses on three case study regions: El Kef, Siliana, and Kairouan, which are located in the northern to northern central part of the country. El Kef is known for its cereal production and olive cultivation. In contrast, Siliana primarily engages in small-scale farming, emphasizing livestock and cereal production. Kairouan's agriculture is dominated by small-scale farms producing vegetables and fruits. These governorates face severe land degradation issues, including water and wind erosion, salinization, loss of soil fertility, loss of vegetation cover, and overexploitation of nutrients. To address these types of land degradation, various farming practices related to agroecology are considered suitable. These practices include conservation agriculture, which includes practices such as no or minimum tillage, permanent soil organic cover, and crop rotation (FAO, 2017); rainwater harvesting (Mekdaschi Studer & Liniger, 2013); crop-livestock integration, which aims to create synergies by using waste of one component as a resource for the other; agroforestry; and lastly, soil erosion control, including structural measures such as bench terraces, vegetative measures, and/ or combined measures such as catchment protection (Sanz et al., 2017).

We focus on rainfed agriculture in the case studies, which represent 92–94% of the utilized agricultural area in the country and contribute to approximately 65% of the total value of agricultural production (MARHP, DGACTA, GIZ, 2019). In 2020, water withdrawal in Tunisia reached 98.11% of the available freshwater resources (FAO, 2023). Additionally, non-conventional water resources, such as desalinated water or treated wastewater, are costly and partly lack social acceptance. Therefore, rainfed agriculture holds significant socio-economic relevance now and will continue to do so in the future.

## 3.3 Empirical Analysis

In the following section, we will first provide an overview of some agroecology initiatives in the country. Next, we will present case studies to understand the farming practices being applied and their relationship to agroecology. Subsequently, we will discuss the soil governance framework within which farmers operate. Finally, we will analyze how the domains of agroecology transformations are represented in the case studies.

### *3.3.1 Agroecology Initiatives in the Case Study Areas*

In recent years, Tunisia has seen the emergence of several initiatives that aim to promote sustainable agriculture practices and improve food sovereignty. Important examples include the Tunisian Network for Agroecology Transition (*Réseau Tunisien de la Transition Agroécologique*), founded in 2023, and the Tunisian Association for Environmental Agriculture. Other examples include the Observatory for Food Sovereignty and the Environment and the Tunisian Association of Permaculture. These initiatives aim to coordinate and accelerate actions related to sustainable agriculture and agroecology, produce and disseminate knowledge on related issues, and support social movements that defend human rights to food, environmental, and agricultural resources. While these initiatives can be subsumed under the broader umbrella of sustainable agriculture, only some explicitly focus on agroecology (Carpentier, 2025). However, all of these initiatives relate to the principles of agroecology. For example, the Tunisian Association of Permaculture inter alia organizes the annual "Peasant Seed Festival," which includes workshops, conferences, and opportunities for exchanging and sharing reproducible seeds. The overall aim of preserving traditional seeds and promoting food sovereignty aligns with agroecology, even though the association operates under the umbrella of permaculture.

In an inventory of agroecology-related initiatives implemented in the country since 1999, Lestrelin and Jaouadi (2022) found that most of these agroecology initiatives are led by the government or international organizations, funded by foreign donors such as FAO, the International Fund for Agricultural Development (IFAD), the Global Environment Facility (GEF), or the German development agency (GIZ) (Requier-Desjardins et al., 2024). A smaller number of initiatives come from civil society organizations, and only a few are grassroots and community-based enterprises (Lestrelin & Jaouadi, 2022). The initial focus of these initiatives was on technical assistance and demonstration activities, like improving soil health and biodiversity or encouraging technical innovations among farmers. In later years, the initiatives became more participatory, including aspects of value chain development and multi-stakeholder platforms (Lestrelin & Jaouadi, 2022). However, Carpentier (2025) argues that many of the agroecology projects in the country are torn between attempts at structural transformation and the exploration of new market opportunities.

Additionally, some agroecology initiatives are also supported by research institutes and internationally funded research projects (see Requier-Desjardins et al., 2024). For example, the agroecology initiative "Transformational Agroecology across Food, Land and Water Systems" and the International Center for Agricultural Research in the Dry Areas (ICARDA) have worked on empowering smallholder olive growers in El Kef by improving productivity, collective action, and market strategies. Another example is the establishment of Agroecological Living Landscapes in El Kef and Siliana by the Consortium of International Agricultural

Research Centers (CGIAR) in 2022, which supports over 1000 beneficiaries and promotes public-private partnerships for a climate-adaptive agricultural transition.

This overview shows that while there are important initiatives on sustainable agriculture, also related to the principles of agroecology, widespread bottom-up processes have not been identified in our literature review. This aligns with the findings of the local case studies below, where we identify important barriers to the emergence of agroecology in the context of soil governance.

### *3.3.2 Tunisian Soil Governance and SLM Practices*

Soil governance in Tunisia is shaped by various legislations, policies, and strategies across sectors, which directly or indirectly influence land management. A key document in this context is the 2017 Strategy for the Development and Conservation of Agricultural Land (hereafter: ACTA Strategy) from the Ministry of Agriculture, aimed at protecting land and strengthening territorial development. The ACTA Strategy inter alia promotes farming practices aligned with agroecology, such as rainwater harvesting methods, crop rotation, agroforestry, and reduced/no-tillage (MARHP, DGACTA, 2017). It fosters farmers' involvement in decision-making and includes capacity-building measures related to agroecology. It also emphasizes the importance of agroecology in combating land degradation. Although the objectives of the strategy are very ambitious, its current status is unclear as it has been pending political approval for several years. In addition, the 1995 Law for the Conservation of Water and Soil regulates and prohibits certain farming practices like overgrazing, and includes financial incentives for water and soil conservation and compensation. Furthermore, the upcoming National Strategy for the Sustainable Development and Management of Forests and Rangelands (2025–2050) aims to strengthen soil and water conservation measures and promote integrated landscape management approaches that stabilize watersheds, curb erosion on cultivated hillsides, and enhance the resilience of agricultural systems. This strategy highlights the increasingly cross-sectoral nature of land governance in Tunisia, where protecting soil and ensuring agricultural sustainability are seen as interdependent objectives. However, no policies or strategies focus solely on agroecology.

These more recent holistic approaches to soil protection contrast with many post-independence agricultural policies. Since the 1960s, water and agricultural policies have primarily aimed at increasing productivity and strengthening agricultural exports by promoting agricultural modernization, large-scale farming, mechanization, and chemical inputs (Thabet, Laajimi, et al., 2015). These policies also promoted monoculture cereal production, which increased vulnerability and dependence on imports (see Tanchum, 2022). These policies reflect a trade-based food security approach, where the country uses exports to finance food imports (Ayeb & Bush, 2019; Gana, 2012). In addition, the Investment Law 2017, or the Fiscal Advantage Law 2017, continues to offer subsidies for investments in irrigation of cereals—water-intensive crops that are not well adapted to most Tunisian contexts—as well

as for creating pastures, rangelands, and planting of fodder and forest shrubs. However, expanding irrigated agriculture has led to significant challenges, including salinization, reduced soil productivity, and depletion of groundwater reserves.

At the local level, we observe that only a few SLM practices in line with agroecology are implemented. These include using individual basins for rainwater collection for fruit trees and reduced tillage, or the occasional construction of erosion benches. However, the use of traditional rainwater harvesting structures is limited to a few farmers, while practices like crop rotation and intercropping have significantly declined or are not applied at all. In contrast, land-degrading practices such as chemical fertilizer and pesticide use, overgrazing, ploughing in the direction of the slope, clearing land and starting fires, as well as cereal monoculture, have been reported. Further drivers of land degradation in the case study areas include urban expansion, sealing fertile agricultural land, along with a severe lack of maintenance of water and soil conservation infrastructure by the state.

### *3.3.3 Analyzing Domains of Agroecology Transformations in Relation to Sustainable Land Management*

In the following, we discuss barriers to agroecology transformations in the three case studies, organized along the six domains of agroecology transformation by Anderson et al. (2019, 2021).

Regarding the domain of **access to land and nature** (Anderson et al., 2021), we identify several structural barriers that hinder the adoption of SLM practices aligned with agroecology. These include the lack of secure property rights and land fragmentation. More specifically, the current land tenure system discourages long-term planning and hinders farmers from confidently investing in sustainable practices, as many small-holders lack formal land titles, face difficulties accessing land, or have to pay relatively high administrative costs to formalize land titles. Interviewees also reported difficulties in accessing other seeds than cereals and the need to buy imported seeds that are poorly adapted to the regional climate. The seed and other input markets in the country are largely controlled by state-owned companies or governmental agencies (Alary et al., 2022). Furthermore, the use of local seeds is restricted as seeds must be registered in an official catalogue that favours exclusive registration of hybrid seeds (Amayed, 2020).[2] By limiting farmers' ability to save, exchange, and use local seeds, the current systems stifle circularity and self-reliance in farming systems, leaving smallholders dependent on external inputs that are often unsuitable for sustainable agriculture. Additionally, inheritance rules lead to land fragmentation, which is considered one of the most pressing drivers of land degradation among the farmers and state actors interviewed. According to customary practices, land is divided among heirs across contour lines, i.e., in the direction of

[2] See also Law no. 99-42 of 10 May 1999 on seed, seedlings, and new plant varieties.

the slope. This division reduces the individual plot sizes and results in land fragmentation, compelling farmers to plough in the direction of the slope rather than adopting the more soil-friendly approach of ploughing along contour lines.

Insecure and unequal access to land directly affects the potential of agroecology transformations in the case study areas because smallholders without formal land titles cannot request subsidies that could serve as incentives to adopt agroecological practices. Furthermore, in particular for farmers with less than 5 ha, subsidies are too low and do not cover their transaction costs for applying. The structure of small-scale farming also results in a higher number of farmers needing to cooperate to implement structural soil protection measures, such as erosion banks, which are only profitable on larger parcels. This reduces the likelihood of achieving an agreement, particularly in a context where collective action is limited. In addition, land fragmentation further strengthens land exodus towards urban areas, leading to land abandonment (MEDD, 2015), thereby also undermining agroecology.

Regarding **knowledge and culture**, the second domain of agroecology transformation (Anderson et al., 2021), our assessments reveal significant gaps in awareness and understanding of land degradation and its underlying drivers. Farmers interviewed often lacked knowledge of how specific practices contribute to land degradation (see also Jalkh, 2024; Jendoubi et al., 2020). For instance, many farmers attributed decreasing yields solely to the lack of chemical inputs, without considering other contributing factors such as soil health. Additionally, many were unaware that practices such as drilling of wells or ploughing in the direction of the slope are legally prohibited. Furthermore, water scarcity is perceived as more urgent and acute than land degradation, leading farmers to prioritize water conservation over land conservation measures. They thereby overlook the potential benefits of integrated approaches to soil and water conservation. Some farmers shared the view that soil degradation issues would be resolved automatically if water scarcity issues were resolved. Furthermore, while some farmers know about soil degradation, they often lack knowledge about adequate measures and their impact on soil.

Furthermore, there is a lack of advisory and extension services in the case study areas. While agricultural extension services are downsized, underfunded, and often lack effective communication strategies (Dhehibi et al., 2020; Mekdaschi Studer et al., 2014), this gap has been partially filled by private companies offering agricultural inputs, such as pesticides, chemical fertilizers, or agricultural equipment. This results in biased extension activities (see also Thabet, Dhehibi, et al., 2015), which can contradict and possibly even undermine agroecological knowledge. Furthermore, traditional knowledge and farming practices by local communities have been neglected and undermined (ITES, 2017). Another critical gap is the lack of access to data on the environmental implications of the agricultural sector, in particular in relation to land degradation. Farmers and public actors, such as the Ministries of Agriculture and Environment, have limited access to actionable information, which hinders informed decision-making and effective policy formulation. Agroecology as a science has gained prominence in recent years in the country (see for example the “Initiative on Agroecology” by the CGIAR). At a recent conference on the science-policy interface, ministries and research institutes identified integrating

scientific research with public policy to advance sustainable agriculture and promote agroecology as essential for addressing environmental and food security challenges. However, in the case study areas, we found no evidence of interaction between researchers and farmers.

Regarding the systems of **economic exchange** (Anderson et al., 2021), we found that farmers face restrictions in their farming and food marketing due to several interrelated factors. First, a lack of financial resources forces farmers to prioritize perceived short-term benefits over long-term advantages, which has been identified as the most important driver of unsustainable farming practices in the case study areas. This is partly because of the time lag between adopting new soil conservation practices and the expected results, such as increased yields or higher productivity, which can take several years to materialize. Therefore, the long-term benefits of soil conservation do not outweigh farmers' perceived short-term costs. Furthermore, the need to cover subsistence expenses inhibits the adoption of more sustainable farming practices (Jendoubi et al., 2020). The situation has been exacerbated by external shocks such as the COVID-19 crisis, an increase in global grain prices, long periods of drought, and Tunisia's fiscal crisis, which caused grain prices for animal feed to rise by between 18 and 46% in 2021 (Tanchum, 2022). As a result, farmers are forced to adopt unsustainable coping strategies, such as overgrazing any area with vegetation to feed their livestock and selling trees to generate additional income, thereby contributing to deforestation.

Second, agribusinesses dominate market structures (Riachi & Martiniello, 2023), constraining farmers in their choice and dictating modes of operation. As mentioned above, farmers depend on imported, inappropriate seeds for monocultures with limited resilience to environmental and economic shocks, particularly in the case of wheat production. Policies heavily favour cereal production, which can exclusively be sold to the state-owned *Office des Céréales.* This office has a monopoly on buying and selling locally produced cereals and regulates the prices throughout the whole value chain (Alary et al., 2022), further limiting farmers' options for food marketing. Furthermore, farmers in the case study areas lack distribution networks that connect actors along the supply chain, and are confronted with poor road infrastructure, which inhibits the distribution of fodder for dairy and cattle farming. Regional markets for sustainably produced goods often do not exist or are inaccessible due to farmers' remote locations, insufficient funds, and lack of infrastructure. Moreover, as farmers are not paid a premium price and information about sustainable local production is not made available to consumers, they see little economic benefit in adopting SLM techniques.

The fourth domain of agroecology transformation concerns **networks** (Anderson et al., 2021). First, we observe that self-organization and cooperation among food system actors are not actively promoted by the public administration. While Tunisia has established so-called agricultural development groups (Groupement de Développement Agricole or GDA) to facilitate the self-organization of natural resource users, these groups are underfunded and lack the necessary support to operate effectively. According to Abidi (2016), responsibility for natural resources has been delegated to user groups without providing the conditions for their

effective operation. Furthermore, GDAs are often perceived with scepticism (Abidi, 2016), as until the 2011 revolution, the ruling party mainly used GDAs to strengthen local control (Mhadhbi, 2023). Thus, for historical and cultural reasons, farmers seem to be suspicious of collectives and self-organization. They also often lack the means and capacities to organize and manage collective endeavours. Furthermore, the centralized system of Tunisia's governance system significantly restricts autonomy of regional and local public actors. The decentralization process under the umbrella of the 2018 adopted "Local Authorities Code" is being challenged by its implementation, as the transfer of responsibilities to the local level has not been accompanied by a transfer of financial and human resources that can be managed independently (Kherigi, 2020). Additionally, important decisions are always made centrally and not always adapted to regional specificities. This lack of autonomous decision-making is further enhanced by the strong dependence of public actors on external funds, with most of the budget allocated to water and soil conservation schemes coming from international cooperation projects.

Regarding **equity**, we observe significant inequalities in the agricultural system, reflected by the unequal distribution of tenure rights to land. Around 75% of farmers cultivate less than 10 hectares, and 65% less than 5 ha, compared to a few large-scale export-oriented farms (Ayeb & Bush, 2019). This results from post-independence policies that favoured access for large agricultural landowners (Ayeb & Bush, 2019: 94). Additionally, there are serious issues of gender inequality, as women face disadvantages in accessing and using land and natural resources (DG NEAR, 2023). This is partly due to customary inheritance practices, where daughters inherit half the share of sons. Furthermore, in particular in rural areas, women often do not claim their inheritance to avoid conflicts or due to social and traditional informal rules. It is estimated that women own less than 5% of the land in Tunisia (Jouini, 2021). Lastly, entire regions and rural areas, including small-scale farmers, have been marginalized by the agricultural policies described above (Riachi & Martiniello, 2023; Thiel et al., 2024), as well as by the "structural absence of the welfare state apparent in lacking or degrading services and physical infrastructure" (Salman, 2017).

The last domain of transformation, **discourses**, is also quite limiting for agroecology transformations (see also Ameur & Leauthaud, 2024). Regarding the discourse among policy-makers, post-independence agricultural policies have been strongly influenced by the modernization paradigm and the related emphasis on food security (Ayeb & Bush, 2019), which still seems to dominate policy decisions (but see Institut Tunisien des Études Stratégiques, 2017). For instance, resources allocated within the Ministry of Agriculture to strengthen food security are earmarked for increasing irrigation for specific crops such as cereals, potatoes, and tomatoes (MARHP, 2019). By prioritizing irrigated agriculture, policies have contributed to the over-extraction of Tunisia's already limited water resources.[3] The potential of rainfed agriculture, which plays a significant role in Tunisian farming

[3] https://data.worldbank.org/indicator/ER.H2O.FWST.ZS?locations=TN (access: 12/18/2024)

**Table 3.2** Summary of empirical findings, clustered along the six domains of agroecology transformation

| | |
|---|---|
| Access to land and nature | Limited access of small-scale farmers to land and natural resources |
| | Land fragmentation |
| Knowledge and culture | Lack of awareness of land degradation and SLM among farmers |
| | Under-resourced state extension services |
| | Agribusinesses are filling the gap of the lack of extension services |
| Systems of economic exchange | Limited financial resources of small-scale farmers |
| | Dependency of farmers on imported and mal-adapted seeds |
| | Limited market access of farmers, lack of distribution networks |
| Networks | Strong centralization |
| Equity | Inheritance laws disadvantage women |
| | Inequitable distribution of and access to resources |
| Discourse | Discourse on food security and the promotion of large-scale, export-oriented irrigated agriculture |
| | Alternative visions for food systems not identified |

Source: Own compilation

systems, particularly in marginalized regions, is thereby overlooked. Moreover, the Ministry of Agriculture's understanding of agroecology seems to be limited to the technical application of isolated farming practices (MARHP & DGACTA, 2017), rather than systemic approaches that include political and transformative dimensions.

At the local level, farmers also prioritize subsidies and structural measures such as dams to address their immediate challenges. Because of the often hopeless economic situation, and the severe droughts in certain parts of the country, there is a strong call from farmers to the state by farmers: "*We are thirsty. We need contributions to improve our situation. We want to have subsidies from the state to help farmers buy machines to practice ploughing. We need solutions for the water problem.*" While this call for state support is both understandable and urgent, we argue that relying solely on technical fixes, such as subsidies or infrastructure projects, risks perpetuating a dependency mindset and overlooks the transformative potential of empowering farmers as active agents of change (Table 3.2).

## 3.4 Discussion and Conclusion

This chapter explored the current status of agroecology initiatives and the potential for future agroecology transformations in Tunisia, using soil governance as an example. We argue that institutions and governance are closely interlinked to agroecology transformation, including the three dimensions of practices, science, and movements towards more sustainable food systems. This is because institutions create the space within which individual choices are made, serving as the foundation for the emergence of agroecological practices and broader political movements.

Several initiatives on sustainable agriculture that align with the principles of agroecology have been identified. However, these are often linked to externally funded projects, while few bottom-up approaches are in place. In the case study areas, we observe that only a few agroecological farming practices are actually implemented by farmers. This is largely due to the institutional framework that hinders agroecological transformations at all levels, from farms to governance. Barriers to agroecology transformations include limited access to land and natural resources for small-scale farmers, compounded by land fragmentation and the systematic exclusion of women, caused inter alia by the country's inheritance laws. Second, there is a lack of knowledge exchange caused by top-down approaches to rural development and agricultural extension. Recent survey findings from Siliana and Kef emphasize the importance of platforms for knowledge exchange, showing that farmers are more inclined to change their farming practices after receiving training in agroecology (Souissi et al., 2024). Third, and perhaps most importantly, the systems of economic exchange and the underlying structures of the political economy—which also cut across the other five domains of transformations—pose significant challenges for agroecology transformations in the case studies. Limited financial resources hinder small-scale farmers from adopting SLM practices or supporting wider changes, as they force farmers to prioritize short-term gains over long-term sustainability.

Fourth, we find that cooperation and self-organization among actors in the food system are not supported by formal and informal institutions, and autonomous decision-making of local government is hindered by the strong centralization of state administration. Fifth, considerations of equity in the case studies are limited. In fragile agricultural contexts such as the case study areas—characterized by land degradation, water scarcity, and economic vulnerability—inequitable access to resources exacerbates poverty, which in turn promotes the unsustainable extraction and use of environmental resources. Inequitable distribution of and access to resources also weakens trust in governance systems, further impeding collective action for SLM. Finally, the discourses surrounding agriculture and food in Tunisia are heavily influenced by historical paradigms around food security (Ayeb & Bush, 2019), which continue to shape policy priorities and resource allocations—admittedly not only in Tunisia but worldwide. We observe a lack of vision about alternative ways of organizing the farming sector by farmers and public actors across sectors and levels of governance. Policymakers are not sufficiently aware of the central role of small-scale, rainfed farming systems in achieving resilient and equitable food systems. Therefore, alternative narratives around food and agriculture, centered on sustainability, resilience, local autonomy, and social equity, are important to shift mindsets and thereby policy priorities and resource allocations.

In conclusion, we argue that a successful agroecology transformation in Tunisia requires a paradigm shift in governance and institutional frameworks, shifting from a rather narrow, technical focus to a transformative approach that acknowledges the political and emancipatory dimensions of agroecology.

## References


Abidi, W. (2016). *Analyse de l'organisation coopérative dans l'agriculture et l'élevage en Tunisie*. Thimarresearchcollectiveonagriculture,environment&labourintheArabworld.https://www.athimar.org/en/articles/details/analyse-de-lorganisation-cooperative-dans-lagriculture-et-lelevage

Alary, V., Frija, A., Ouerghemmi, H., Idoudi, Z., & Rudiger, U. (2022). *Context assessment for agroecology transformation in the Tunisian living landscape*. International Center for Agricultural Research in the Dry Areas.

Amayed, A. (2020). *Local seeds: a history of dispossession*. https://houloul.org/en/2020/12/12/local-seeds-a-hi

Ameur, F., Amichi, H., & Leauthaud, C. (2020). Agroecology in North African irrigated plains? Mapping promising practices and characterizing farmers' underlying logics. *Regional Environmental Change, 20*(4). https://doi.org/10.1007/s10113-020-01719-1

Ameur, F., & Leauthaud, C. (2024). Assessing the integration of agroecological principles in smallholder farming systems in North African irrigated plains. *Agroecology and Sustainable Food Systems, 00*(00), 1–26. https://doi.org/10.1080/21683565.2024.2417266

Anderson, C. R., Bruil, J., Chappell, M. J., Kiss, C., & Pimbert, M. P. (2019). From transition to domains of transformation: Getting to sustainable and just food systems through agroecology. *Sustainability, 11*(19). https://doi.org/10.3390/su11195272

Anderson, C. R., Bruil, J., Chappell, M. J., Kiss, C., & Pimbert, M. P. (2021). *Agroecology now! Transformations towards more just and sustainable food systems*. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-61315-0

Ayeb, H., & Bush, R. (2019). *Food insecurity and revolution in the Middle East and North Africa*. Cambridge University Press. https://doi.org/10.2307/j.ctvpr7r45

Barrios, E., Gemmill-Herren, B., Bicksler, A., Siliprandi, E., Brathwaite, R., Moller, S., Batello, C., & Tittonell, P. (2020). The 10 elements of agroecology: Enabling transitions towards sustainable agriculture and food systems through visual narratives. *Ecosystems and People, 16*(1), 230–247. https://doi.org/10.1080/26395916.2020.1808705

Béné, C. (2022). Why the Great Food Transformation may not happen – A deep-dive into our food systems' political economy, controversies and politics of evidence. *World Development, 154*(June), 105881. https://doi.org/10.1016/j.worlddev.2022.105881

Bezner Kerr, R., Liebert, J., Kansanga, M., & Kpienbaareh, D. (2022). Human and social values in agroecology. *Elementa: Science of the Anthropocene, 10*(1), 1–24. https://doi.org/10.1525/elementa.2021.00090

Carpentier, I. (2025). Policies and development models for "sustainable" agriculture in Tunisia an "agroecological transition" in question. *Agroecology and Sustainable Food Systems, 00*(00), 1–22. https://doi.org/10.1080/21683565.2025.2489428

Chebbi, H. E., Pellissier, J. -P., Khechimi, W., & Rolland, J. -P. (2019). Rapport de synthèse sur l'agriculture en Tunisie. In *CIHEAM-IAMM*.

Dhehibi, B., Rudiger, U., Moyo, H. P., & Dhraief, M. Z. (2020). Agricultural technology transfer preferences of smallholder farmers in Tunisia's arid regions. *Susta, 12*(1), 1–18.

Directorate-General for Neighbourhood and Enlargement Negotiations (DG NEAR). (2023). *Annex II—Document d'action relatif au Programme d'Appui à la Sécurité Alimentaire durable en Tunisie (PASAT)* (pp. 1–27).

Dumont, A. M., Vanloqueren, G., Stassart, P. M., & Baret, P. V. (2016). Clarifying the socioeconomic dimensions of agroecology: between principles and practices. *Agroecology and Sustainable Food Systems, 40*(1), 24–47. https://doi.org/10.1080/21683565.2015.1089967

FAO. (2017). *Conservation agriculture*. https://doi.org/10.1007/978-3-319-11620-4

FAO. (2019). *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forests in the context of national food security*. https://doi.org/10.4060/i2801e

FAO. (2023). *Level of water stress: freshwater withdrawal as a proportion of available freshwater resources—Tunisia*. https://data.worldbank.org/indicator/ER.H2O.FWST.ZS?locations=TN

FAO & ITPS. (2015). *Status of the world's soil resources. Regional assessment of soil changes in the Near East and North Africa*. https://openknowledge.fao.org/handle/20.500.14283/bc602e

FAO, ITPS, GSBI, CBD, & EC. (2020). *State of knowledge of soil biodiversity—Status, challenges and potentialities*. FAO. https://doi.org/10.4060/cb1928en

FAO Regional Conference for the Near East. (2022). *Greening agriculture: Towards sustainable recovery and climate change action*.

Gana, A. (2012). The rural and agricultural roots of the Tunisian revolution: When food security matters. *The International Journal of Sociology of Agriculture and Food, 19*(2), 201–213. https://doi.org/10.48416/ijsaf.v19i2.224

Gliessman, S. (2016). Transforming food systems with agroecology. *Agroecology and Sustainable Food Systems, 40*(3), 187–189. https://doi.org/10.1080/21683565.2015.1130765

Goetz, A., Hussein, H., & Thiel, A. (2023). Polycentric governance and agroecological practices in the MENA region: insights from Lebanon, Morocco and Tunisia. *International Journal of Water Resources Development*, 1–16. https://doi.org/10.1080/07900627.2023.2260902

González de Molina, M., Petersen, P. F., Peña, F. G., & Caporal, F. R. (2019). *Political agroecology. Advancing the transition to sustainable food systems*. CRC Press. https://doi.org/10.1201/9780429428821

High Level Panel of Experts on Food Security and Nutrition (HLPE). (2019). *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition*. https://www.fao.org/agroecology/database/detail/en/c/1242141/

Institut Tunisien des Études Stratégiques (ITES). (2017). *Revue stratégique de la sécurité alimentaire et nutritionnelle en Tunisie*. https://shs.hal.science/halshs-03610899/file/le livre publié par ITES.pdf

IPES-Food. (2022). *Desertification, land degradation, and the potential of agroecology*.

Jalkh, R. (2024). *Analysis of agroecological perspectives in North African intersectoral public policies. A review of trends, strengths and weaknesses*. NATAE project report. https://doi.org/10.5281/zenodo.12770882

Jebari, S., Berndtsson, R., & Bahri, A. (2015). Challenges of traditional rainwater harvesting systems in Tunisia. *Middle East Critique, 24*(3), 289–306. https://doi.org/10.1080/19436149.2015.1046707

Jendoubi, D., Hossain, M. S., Giger, M., Tomićević-Dubljević, J., Ouessar, M., Liniger, H., & Speranza, C. I. (2020). Local livelihoods and land users' perceptions of land degradation in northwest Tunisia. *Environmental Development, 33*(March). https://doi.org/10.1016/j.envdev.2020.100507

Jouini, H. (2021). *Women struggle for land rights and equal inheritance in Tunisia*. https://capiremov.org/en/analysis/women-struggle-for-land-rights-and-equal-inheritance-in-tunisia/

Kherigi, I. (2020). Tunisia's decentralization reforms: The gap between ideas and implementation. In *The dynamics of decentralization in the MENA: Processes, outcomes, and obstacles* (pp. 54–66). University of Gothenburg, Program on Governance and Local Development.

Lestrelin, G., & Jaouadi, R. (2022). *Inventory of agroecology-related initiatives in Tunisia* (pp. 1–10). International Center for Agricultural Research in the Dry Areas.

Liniger, H., Mekdaschi Studer, R., Hauert, C., & Gurtner, M. (2011). *Sustainable Land Management in Practice – Guidelines and best Practices for Sub-Saharan Africa*. TerrAfrica, WOCAT, FAO. https://www.fao.org/4/i1861e/i1861e00.htm

Mayring, P. (2000). Qualitative content analysis. *Forum: Qualitative Social Research, 1*(2). https://doi.org/10.17169/fqs-1.2.1089

Mekdaschi Studer, R., & Liniger, H. (2013). *Water harvesting. Guidelines to good practice*. Centre for Development and Environment. https://doi.org/10.4135/9781446247501.n4126

Mekdaschi Studer, R., Zähringer, J., & Gurtner, M. (2014). *Diagnostic and evaluation of the agricultural potentials and examples of good soil and water conservation and soil defence and restoration practices adapted to the MENA desert zones*.

Mhadhbi, F. (2023). Understand factors influencing the development of the social and solidarity economy in African countries: A case study in rural Tunisia ? *Preprints*. https://doi.org/10.20944/preprints202304.0329.v2

Ministère de l'Agriculture des Ressources Hydrauliques et de la Pêche (MARHP). (2019). *Projet annuel de performance des programmes des missions agriculture, ressources hydrauliques et pêche. Année 2020*. https://de.scribd.com/document/508029296/PAP-2020-Agriculture

Ministère de l'Agriculture des Ressources Hydrauliques et de la Pêche & Direction Génerale de l'Aménagement et de la Conservation des Terres Agricoles (MARHP & DGACTA). (2017). *Elaboration de la Stratégie de Conservation des eaux et des sols de la Tunisie*.

Ministère de l'Agriculture des Ressources Hydrauliques et de la Pêche, Direction Génerale de l'Aménagement et de la Conservation des Terres Agricoles, & Deutsche Gesellschaft für Internationale Zusammenarbeit (MARHP, DGACTA, & GIZ). (2019). *Diagnostic et perspectives de l'agriculture pluviale en Tunisie. Rapport final*.

Ministère de l'Environement. (2023). *Stratégie nationale de transition écologique: Vision, objectifs, actions et mesures*. https://www.environnement.gov.tn/fileadmin/user_upload/SNTE_version_francaise_.pdf

Ministère de l'Environement et du Développement Durable (MEDD). (2015). *Mise en place d'un système de gestion des connaissances sur les meilleures pratiques en matière de gestion durable des terres au gouvernorat de Siliana. Rapport Phase I: Inventaire et compilation des données*.

Nachtergaele, F., Petri, M., Biancalani, R., Van Lynden, G., Van Velthuizen, H., & Bloise, M. (2010). *Global land degradation information system (GLADIS)*.

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press. https://doi.org/10.1017/CBO9780511808678

Ostrom, E. (1990). *Governing the commons*. Cambridge University Press. https://doi.org/10.1017/CBO9780511807763

Pimbert, M. P. (2018). Global status of agroecology. *Economic & Political Weekly, 53*(41), 52–57.

Requier-Desjardins, M., Boughamoura, O., & Lemaître-Curri, E. (2024). Characterizing agroecology in North Africa, a review of 88 sustainable agriculture projects. *Land, 13*(9), 1457. https://doi.org/10.3390/land13091457

Riachi, R., & Martiniello, G. (2023). Manufactured regional crises: The Middle East and North Africa under global food regimes. *Journal of Agrarian Change, 23*, 792–810. https://doi.org/10.1111/joac.12547

Salman, L. (2017). What we talk about when we talk about decentralization? Insights from post-revolution Tunisia. *L'Année Du Maghreb, 16*, 91–108. https://doi.org/10.4000/anneemaghreb.2975

Sanz, M. J., Vente, J. d., Chotte, J. -L., Bernoux, M., Kust, G., Ruiz, I., Almagro, M., Alloza, J. -A., Vallejo, R., Castillo, V., Hebel, A., & Akhtar-Schuster, M. (2017). *Sustainable land management contribution to successful land-based climate change adaptation and mitigation. A report of the science-policy interface*. United Nations Convention to Combat Desertification. https://www.unccd.int/sites/default/files/documents/2017-09/UNCCD_Report_SLM_web_v2.pdf

Schütze, N., Andreas, T., Buhrow, A., Fouzai, A., & Götz, A. (2025). Soil governance in Tunisia: analyzing the potentials for agroecology transformations. *Agroecology and Sustainable Food Systems*, 1–28. https://doi.org/10.1080/21683565.2025.2456912

Souissi, A., Dhehibi, B., Oumer, A. M., Mejri, R., Frija, A., Zlaoui, M., & Dhraief, M. Z. (2024). Linking farmers' perceptions and management decision toward sustainable agroecological transition: evidence from rural Tunisia. *Frontiers in Nutrition, 11*(May), 1–17. https://doi.org/10.3389/fnut.2024.1389007

Tanchum, M. (2022). *The fragile state of food security in the Maghreb: Implication of the 2021 cereal grains crisis in Tunisia, Algeria, and Morocco*. Middle East Institute. https://www.mei.edu/publications/fragile-state-food-security-maghreb-implication-2021-cereal-grains-crisis-tunisia

Thabet, B., Dhehibi, B., Kassam, S., & Aw-Hassan, A. (2015). Good intensions and hard realities: achievements and challenges in agricultural extension systems in Tunisia. *International Journal of Agricultural Extension, 3*(3), 209–216.

Thabet, B., Laajimi, A., Thabet, C., & Bensaïd, M. (2015). Agricultural and food policies in Tunisia: From a seemingly solid performance to unsustainable revealed achievements. In M. Petit, E. Montaigne, F. El Hadad-Gauthier, J.-M. García Álvarez-Coque, K. Mattas, & S. Mili (Eds.), *Sustainable agricultural development* (pp. 83–101). Springer. https://doi.org/10.1007/978-3-319-17813-4_4

Thiel, A., Schütze, N., Buhrow, A., & Fouzai, A. (2024). *State infrastructural power in a neopatrimonialist democratization context: Why Tunisian sustainable land management fails* (pp. 1–32). *Review of Policy Research*. https://doi.org/10.1111/ropr.12617

United Nations. (2021). *Policy brief. Governance of food systems transformation*. https://www.unfoodsystemshub.org/docs/unfoodsystemslibraries/fss-community/chapter-2/policybrief_governanceunfss.pdf?sfvrsn=edae3afc_1

Vatn, A. (2005). Rationality, institutions and environmental policy. *Ecological Economics, 55*(2), 203–217. https://doi.org/10.1016/j.ecolecon.2004.12.001

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., & David, C. (2009). Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development, 29*(4), 503–515. https://doi.org/10.1051/agro/2009004

World Bank. (2019). *Sustainable land management and restoration in the Middle East and North Africa region. Issues, challenges, and recommendations*. The World Bank.

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# Chapter 4
# Decolonizing Agriculture: An Approach from Mayan Philosophy and Territory




**Paulina Martínez Isidro, Aurelio Sánchez Suárez, Daniel G. Cantón Puerto, and Nayeli Uicab**

**Abstract** The realities faced by indigenous peoples who preserve ancestral knowledge of land management—de facto agroecology—include the evolving services surrounding local seeds and the in-situ conservation of agrobiodiversity. For centuries, the commercialization of rural areas has prioritized agriculture to enhance productivity, profitability, and the economic growth of countries (FAO, 2006, 2023). On the one hand, the United Nations (UN) advocates that sustainable food and agriculture contribute to the four pillars of food security: availability, access, utilization, and stability. On the other hand, it emphasizes three dimensions of sustainability: environmental, social, and economic. Likewise, the FAO (2023) promotes sustainable food and agriculture to help countries worldwide achieve Zero Hunger and meet the Sustainable Development Goals by 2030. In contrast, the current capitalist model positions natural resources as inexhaustible and assumes they are recoverable using chemicals. This perspective undermines the identity and sovereignty of agriculture and rural areas. It also contributes to the erosion of resources and knowledge, including the philosophical beliefs of Mayan women and their relationship with the land. Understanding agriculture as a vital element for indigenous peoples supports the concept of food sovereignty. This principle means indigenous people have the right to establish their policies and strategies for food production, distribution, and consumption to guarantee that food is available for the entire community, based on small- and medium-sized production. It emphasizes the importance of respecting their own cultural practices and the diverse forms of agricultural

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production, marketing, and management of rural areas (FAO, 2006) within indigenous communities. In the state of Yucatán, Mexico, communities, such as Yaxunah, practice agriculture rooted in ancestral knowledge and a unique vision perspective on natural resources. One of the main characteristics of sustainable agriculture is its respect for the cycles of nature: the land's rest period, rainfall patterns, lunar phases, and types of seeds used. This understanding transcends the modern concept of agriculture.

**Keywords** Women · Grounded theory · Traditional knowledge

## 4.1 The Decolonization of Agriculture

Decolonization is a process of rupture for colonized peoples seeking to reclaim their political, economic, cultural, epistemic, and territorial autonomy in the face of global power structures and Western influences (Fanon, 1961; Lugones, 2008; Maldonado-Torres, 2007; Mignolo, 2010; Quijano, 2000; Sousa Santos, 2014; Tuck & Yang, 2012). This process goes beyond the mere achievement of formal independence; it demands a radical transformation of power relations, ways of life, systems of knowledge, and notions of subjectivity that persist under colonialism.

The decolonization of agriculture is an ongoing process that requires the active participation of communities, along with respect for and recognition of local and traditional agrarian cultures, knowledge, and systems. Governments must also engage through inclusive public policies that disrupt the utilitarian model of agricultural production—one that extracts natural and social resources to fit within a standardized global framework, neglecting the particular and unique characteristics of each nation, its resources, land, society, and people.

This process involves the recovery of traditional, peasant, and ancestral knowledge, which can contribute to restoring the fertility and resilience of natural ecosystems. Equally essential is the defense of community rights—particularly the sovereignty of Indigenous peoples and their territorial rights—to produce their own food, known as food sovereignty (Bellon, 2014; Lugones, 2008; Mignolo, 2010; Quijano, 2000; Shiva, 2000). For a successful decolonization process, communities must manage their territories, food systems, and knowledge autonomously. It is also crucial to recognize the role of women in agriculture, as well as the contributions of all family members, while valuing the scientific relevance of ancestral knowledge in managing agricultural biodiversity (Bellon, 2014; Lugones, 2008; Mignolo, 2010; Quijano, 2000; Shiva, 2000).

Industrial agriculture, increasingly adopted on a global scale, places tremendous pressure on rural natural resources by prioritizing yield and productivity over ecological regeneration. In Mexico, the study by Hernández Solano et al. (2021) documents that the industrialization of the maize–milpa agricultural system has had contradictory effects: while yields have increased, these gains have been achieved "at the expense of natural resources" (Hernández Solano et al., 2021). Moreover, according to the Food and Agriculture Organization of the United Nations (FAO,

2011), approximately 14 % of the world's food is lost between harvest and retail, and an additional 17–19% is wasted at the retail, food service, and household levels—amounting to nearly 1.3 billion tons per year, or roughly one-third of global food production. These enormous volumes of food loss and waste indicate that vast quantities of land, water, energy, and capital are invested in food that is ultimately discarded, thus amplifying the ecological footprint of the industrial agricultural model and deepening the degradation of rural environments. Industrial corporate models, in essence, seek private profit and shareholder value under the discourse of "national development," which fundamentally contrasts with traditional, community-based production in territories often labeled as "remote" or "marginal" to modernity.

To achieve the decoloniality of agricultural production, it is essential to recognize that multiple paradigms coexist, among them capitalist, agro-industrial, and colonial models. In Mexico—particularly in Yucatán—many communities maintain a way of life distinct from the urban, Westernized model. It is therefore imperative for the State to acknowledge the internal visions of these communities in order to revalue traditional, peasant, and ancestral agricultural knowledge, emphasizing the defense of territory, food sovereignty, and non-extractive, reciprocal relationships with nature. This perspective should be grounded in the philosophical foundations of Indigenous peoples across the world (see Fig. 4.1). Industrialization and the standardization of lifestyles should not be considered the ultimate goal of development if their collateral effects involve the degradation of natural resources—and, consequently, the deterioration of public and ecological health in the medium term.

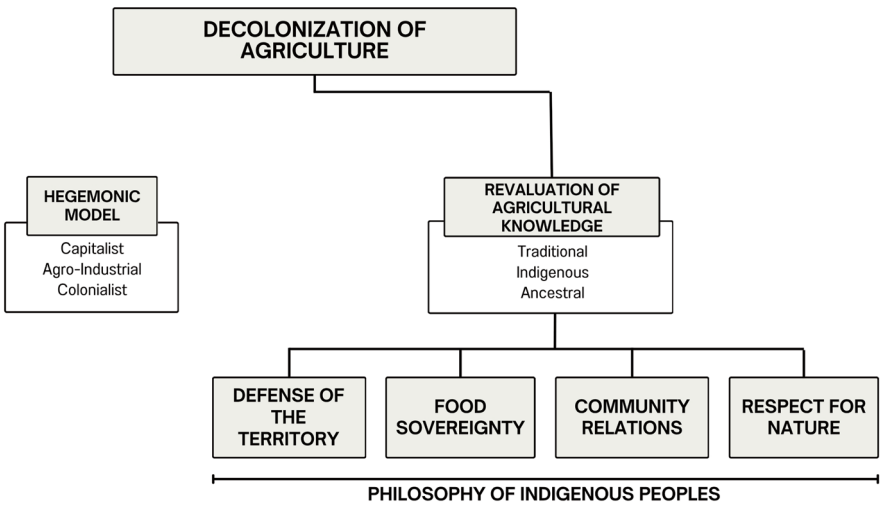



**Fig. 4.1** Decolonization of agriculture. Source: Prepared by the authors based on Shiva (2000), Quijano (2000), Lugones (2008), Bellon (2014), Mignolo (2010)

## 4.2 Mayan Philosophy

Mayan philosophy encompasses various aspects, including the creation of the world, the nature of existence, the heart, thought, and the interconnectedness of all things. It emphasizes the "we" (highlighting the idea of non-individuality and the importance of living in community). This philosophy also addresses the role of creators and supreme beings. Mayan thought demonstrates that existence and knowledge are deeply intertwined with the absolute Being (which can refer to God, the gods, or progenitors), nature, and the heart. Respecting what has been bestowed by these entities is seen as the path to understanding how to inhabit the world and everything within it, as well as the various forms of existence found in the earthly world (Hernández, 2009). Life is understood through the relationships individuals have with their surroundings. The actions of the Mayan people are linked to the concept of "we," which encompasses both humans and all living things that possess a heart. Everything that shares their world has a heart, and for that reason, they live. The term "we" does not have a literal translation in Spanish, as it can also be part of the concept of collectivity. In the Tojolabal Mayan language, the word "*tik, tik, tik*" expresses plurality, reflecting how people express themselves, not as individuals but as part of a collective (Lenkersdorf, 2005).

This knowledge shows that the Mayans are aware that they are cohabiting with other elements they must respect, where everyone is a subject living in a territory to coexist peacefully, far from domination or any forms of power. Nature takes on a meaningful role, our Mother Earth, which goes beyond being the environment or context; she is the one who gives life and sustains life. In Mayan philosophy, there is an intersubjective subjectivity (subject-subject) instead of a subject-object relationship (Lenkersdorf, 2005). According to Sánchez et al. (2021), one way to see this subject-subject relationship is when people move into the guano house; it comes to life and dies after completing a life cycle. The "we" is part of the Mayan philosophy that reminds us that they are a community, not only with other people, but with everything that has a heart, that has life, and that within this community, there is a deep sense of responsibility and care for the benefit of all. Listening to others, to things that have life, leads them to learn more and reflect on life. Thus, every act, everything created with things that have a heart, has a greater meaning for the reason they were made (Martínez Isidro, 2022).

Another important part of Mayan philosophy is the concept of inhabiting the territory. Their understanding of life and the world has created deep bonds of respect and correspondence with nature and the people who inhabit it, as well as with the land's spiritual owners, given that each piece of land has one (Sánchez et al., 2021). It is now understood that, although people are considered the landowners from a Western perspective, they recognize that what exists and lives within them—including the space—is not truly theirs. Instead, they believe that their true owners (gods) also reside within them, so they request, permit, and offer thanks and respect.

When discussing "we" in the Milpa, it is important to consider the sociopolitical context to identify those who hold authority in the communities, specifically the

decision-makers. Thus, "we" refers to the community's internal authorities, specifically the Tojolabal. The term "government" in Tojolabal Mayan means "those who work." Work is an activity performed by everyone within the Mayan community in Chiapas. In this community, everyone is working (Lenkersdorf, 2005).

Work is defined in three important aspects, which hold special significance in Mayan philosophy. These are related to the economic, religious, and political aspects, respectively: when a Milpa is created, it involves working for Mother Earth; the saints, ancestors, and progenitors, both in Christianity and in Mayan tradition; and the community, including governance.

These elements are closely linked and depend on each other, because working in the Milpa requires working for Mother Earth, and those who do it are the community. For the community, work is a shared activity that everyone must participate in. So, when we talk about governing, it does not imply a separate activity that denotes power but reflects what everyone expects and does: work. Those who govern in the communities are not those who give orders, but rather from the community's "we" perspective. Unlike the familiar concept of rulers, under the "we," there are no levels of superiority; instead, they are governed by a sense of unity. Rulers are subject to the decisions of those they govern (Lenkersdorf, 2005). In Tojolabal philosophy, there is no hierarchical order or antagonistic classes; there is a hierarchy of respect, which is more related to age and elders. Elders are considered a source of knowledge and experience, preserved across generations to guide the community. The places where the Mayan people farm—the field, the Milpa, and the Solar—are located within the territory granted by the supreme beings. The concept of territory from the Mayan worldview goes beyond the Western idea of a geographical space marked by political borders. For the Mayan people, territory is a network of relationships between the human community, living beings, natural elements, and spiritual forces. It is a sacred space where life in all its forms connects and sustains one another (Sánchez, 2019).

According to Sánchez (2019), territory can be viewed from the following perspectives: sacred space, community memory, relationship with nature, autonomy, and resistance. It is considered a sacred space because it not only provides material sustenance but also connects communities with their deities and ancestors, serving as the heart of community and spiritual life for the Mayan people. Community memory encompasses the historical memory of the Mayan people and forms the foundation for their traditions, ceremonies, and struggles. Each location within the territory holds specific meaning, either due to its connection with ancestors or because it functions as a ceremonial space. The relationship with nature is rooted in viewing the territory not as a resource to be exploited but as a living entity that must be protected, as reflected in practices such as the Milpa and rituals dedicated to natural elements like water, wind, and sun. Autonomy is essential for the self-determination of indigenous peoples; without territory, there is no way to sustain their ways of life, knowledge systems, or social organizations. Finally, resistance involves defending the territory as a means of resisting colonization, dispossession, and exploitation—preserving their culture, spirituality, and rights.

## 4.3 Women and Mayan Agriculture

Women play a fundamental role in Maya territory, closely linked to activities such as knowledge transmission, on-site teaching, and strengthening social bonds with people and nature. According to Mariaca et al. (2010), Mariaca (2012), Bellon (2014), and Hernández (2009), women are key and multifaceted; along with men and children, they are essential to agriculture as guardians of the resources bestowed upon them by the gods and nature. Furthermore, older women and men are known as the elders and are respected for their accumulated knowledge and for their seniority. Women's work encompasses all stages of agriculture, from pre-planting to harvest. Their importance lies in key aspects of conservation: they are responsible for subsistence crops that ensure family food security, they act as guardians of traditional knowledge related to agricultural practices, seed selection and conservation, and they oversee the management of land resources. Their work is crucial for the sustainability of family farming because, in addition to agriculture, women also manage other resources such as gardens, medicinal plants, and animal husbandry, thus contributing to food diversity and the family economy.

Women often participate in community groups and cooperatives, fostering solidarity and knowledge sharing, which strengthens social cohesion and the capacity to respond to challenges. Despite their important role, women face challenges such as gender inequality, limited access to resources, and, to some extent, restrictions on decision-making. Rural women face different situations than urban women. However, their resilience and adaptability are fundamental to the survival of their communities.

## 4.4 Methodology

The qualitative approach is a way to understand social and human phenomena in depth, capturing their complexity and the meaning they have for the individuals involved. It focuses on exploring the meaning individuals attribute to their experiences, behaviours, interactions, and environments (Pérez, 2012; Schettini & Cortazzo, 2015; Strauss & Corbin, 2002). Thus, to understand the characteristics of agriculture from the perspective of those living in Mayan communities, a qualitative approach was used, employing the grounded theory method, which enables the development of theoretical explanations based on empirical data.

- Step 1: Identify people who practice agriculture with the help of community resident acting as a key informant.
- Step 2: Engage with the community to build an understanding of agriculture through dialogue. Semi-structured interviews are conducted in designated spaces, using field notes, audio recordings, and photos.
- Step 3: Data analysis begins, initial codes are identified, findings related to the topic are presented, and feedback is provided on how the concepts are understood.

- Step 4: Conduct in-depth interviews with the people identified in Step 1, followed by data analysis, data coding, categorization, and then presentation of findings and feedback.

## 4.5 Analysis of the Results

Mayan agriculture comprises multiple interrelated elements and goes beyond a simple production process; these elements cannot be studied in isolation. In this case, it is divided into two parts: the milpa and the solar. The milpa is the area in the forest where corn and other crops such as squash, beans, tomatoes, and chili peppers are planted; the number of crops can vary depending on the farmer. The solar is a space on the property of the house where tomatoes, radishes, onions, squash, cilantro, chili peppers, cucumbers, beans, and others are grown. Both systems are characterized by polyculture; in the case of the milpa, five to six varieties of the aforementioned species are planted (see Fig. 4.2).

Agriculture extends to the territories of each community member: the forest, the milpa (cornfield), and the family garden, which are sometimes shared with parents, uncles, siblings, and children. People demonstrate a respect for their environment, which translates into a characteristic approach to agriculture. According to Altieri (2001), agroecology seeks to balance the components involved in complex ecosystem processes, considering the ecological and social levels of coevolution, structure,

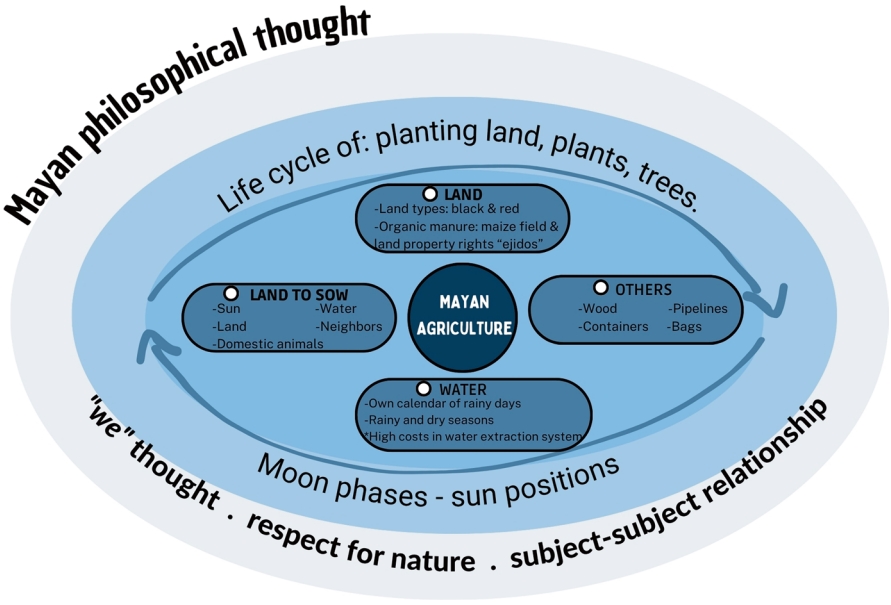



**Fig. 4.2** Agriculture from the perspective of Mayan philosophy. Source: Prepared by authors

and function. Altieri (2001) proposes strategies such as crop rotation, cover crops, polycultures, mixed cropping, and the introduction of animals. Research shows that Mayan communities have used these strategies for thousands of years, dating back to the time of the ancient Maya, approximately 3500 years ago. This is linked to the Mayan philosophy that everything is alive, and crop rotation is practiced allowing the land to rest and once recovered, be cultivated again. It is from this understanding of life that they achieved food sovereignty for an entire civilization.

This type of agriculture comes closer to food sovereignty, reducing dependence on highly processed products and promoting a diet rich in nutrients essential for the body. However, being a low-production system, it departs from utilitarian and extractive economic models, thus guaranteeing food security for the families who practice it. This system is not scalable to an agro-industrial or extensive level, as its objectives differ from the outset. In general, Mayan agriculture is imperfect, as the harvest varies in size and shape and does not meet market quality standards; inefficient, because its yield does not correspond to the amount planted per square meter and the harvest is imperfect; it is not profitable in terms of raw materials, labour, and direct production costs; and it requires considerable dedication. Nevertheless, the nutrients it provides to consumers are superior to those of products grown in other environments.

While there is no open resistance to the Westernization of Mayan farmers in rural areas, it is observed that they adopt and adapt the knowledge and tools that are useful to them in their activities, and they use hybrid seeds that are foreign to them and not functional outside the context in which they were developed. The natural evaluation of endemic seeds lies in the hands of Mayan farmers; for years they have adapted these seeds to environmental changes through observation, care, and preservation. Therefore, there is great concern about the loss of ancestral agricultural knowledge, native seeds, and the impact of all the changes that have occurred on the environment, according to the community's perception: water contaminated by industry, arid lands, and changes in weather patterns.

## 4.6 Expressions of Decolonization and Adaptations of the West

The Maya people are open to listening to those who bring them knowledge and techniques for working in the fields. In this case, those who work in the fields gain this knowledge through inheritance from their grandparents and parents. This knowledge is learned from childhood when they help their parents with agricultural tasks around their homes. Additionally, they have also gained knowledge through public policy programs, higher education institutions (HEIs), research institutions, non-governmental organizations (NGOs), and civil society organizations (CSOs). Among the principal contributions promoted by these organizations are technological innovations, including biological inputs such as diverse seed varieties;

agronomic knowledge, particularly techniques for fertilization and pest control; and material and financial resources, encompassing tools and equipment intended to enhance agricultural labour. They have also introduced chemical inputs such as herbicides and synthetic fertilizers. The incorporation of these technologies has sought to increase the productivity of Mayan agriculture and to align local agricultural practices with state-level objectives aimed at improving rural living conditions—objectives that are further complicated by the mounting challenges of climate change, now visibly reflected in soil degradation, a condition largely absent in pre-colonial periods.

However, most of these interventions have been conceptualized from an external, top-down perspective that does not fully account for the actual needs, priorities, and socio-ecological dynamics within Mayan communities. Fieldwork conducted for this study reveals that both women and men, in their everyday domestic and agricultural activities, selectively adopt and adapt certain externally promoted practices. Their decisions are guided by longstanding familial and community-based knowledge systems—forms of experiential and intergenerational expertise that frequently surpass and reframe the relevance of externally introduced technical knowledge.

Communities adopt the best practices that, according to their experience, work for them in the fields. A clear example is creating organic compost from uneaten food waste. In this case, the food prepared is tailored to the needs of each family, minimizing waste. Instead, they rely on the forest, a place where they gain fertile land that has rested for years (where there is free-range livestock and land fertilized with leaves), knowledge passed down by their ancestors.

Regarding knowledge, not only are agricultural methods passed on, but also the elements necessary for living. These are divided into two main aspects: beliefs and philosophical thought. Beliefs relate to ceremonies and rituals, while Mayan philosophical thought includes their understanding of life, respect for nature, and reverence for supreme beings.

## 4.7 Expressions of Mayan Philosophy

The ancient members of the community understood the importance of the changes occurring in the land because they observed everything, analyzed the consequences of their actions, and related them to the knowledge passed down by their ancestors. In Mayan culture and way of life, the transmission of knowledge from generation to generation is based on reflection and observation. Everything that happens and everything that exists has a purpose, and there are connections between them (Hernández, 1999). People maintain a profound relationship with nature, grounded in the recognition that nature constitutes a living system—one that requires periods of rest, regeneration, and, ultimately, experiences cycles of decline and death.

According to Hernández (2009), Mayan knowledge is closely linked to the Absolute Being (God, the gods, the progenitors), nature, and the heart. Thus, by combining all these elements, respect for what has been bestowed upon them leads

to a way of inhabiting the world that allows them to understand what exists within it and to relate to other forms of earthly existence, in community as subjects.

The objectives that guide commercial enterprises—particularly within the logic of large-scale capitalism, where profit maximization is paramount—differ fundamentally from the purposes of the Maya. For the Maya, agriculture and what stems from it, such as cultivation, is not inherently equivalent to the pursuit of profit; rather, it represents a cyclical and relational process. When the land bears fruit, the result is experienced as a source of joy and gratitude toward the supreme beings, as it is understood that nature has given life. Families benefit from fresh, chemical-free food that contributes to the well-being of the household, strengthens food security, and ensures the continuity and evolution of seeds. Even in years of abundant harvests, farmers reserve the best seeds, selected according to their experience, for subsequent planting cycles.

Their agricultural practices, like their daily activities, reflect a sophisticated understanding of life that is grounded in careful observation, deliberation, and intergenerational knowledge transmission. For centuries, Maya communities have observed and interpreted the dynamics of their environment, recognizing that their actions carry consequences for the land. Contemporary research in Indigenous communities has increasingly documented local terminologies, classifications, and concepts that correspond to scientific knowledge systems formalized only in recent decades, yet that Maya peoples have applied for centuries—long before the Spanish conquest (Martínez, 2020).

## 4.8 Expressions of Inhabiting the Territory

Agriculture is practiced based on knowledge of the territory one inhabits. This territory extends beyond the space of the house and yard, also including areas where activities such as the milpa (cornfield) are carried out, and lands like the forest. The areas chosen for planting must have fertile or living soils, recovered from previous crops and suitable for cultivation (such as red or black soils). When selecting a planting site, it must have sufficient sunlight, adequate solar radiation, and appropriate soil and water conditions, with proper management. Regarding sunlight, a location with access to sunlight is preferred to avoid cutting down existing fruit or timber trees. The habitat of existing trees, such as fruit and timber trees, must be respected. Another important factor is water; a site with access to water is essential for successful planting. Regarding soil characteristics, three main types are considered: red soil, black soil, and clay soils. It is worth noting that in recent decades, changes have occurred that did not exist before and have affected these processes.

It is believed that every element present in the land used for agriculture fulfils a function in the ecosystem and must be conserved. When any of these elements becomes uncontrolled, community members recognize that something harmful is happening in nature, such as when wild animals leave their habitat and are observed in the center of the community. Sánchez et al. (2021) mention that the use of natural

resources transforms the home into an extension of the forest, like what occurs in the Milpa and Solar systems. That is, the Mayan house is built with resources from the land and becomes a source of life for its inhabitants; it remains an entity that must be respected. Protecting what exists is part of their identity as a people and reflects what has been bestowed upon them by God, the gods, or supreme beings.

## 4.9 Nature

In nature, everything has its time, just like the cycle of life. The land, after being cultivated for most of the year, must rest. Crops are rotated to other parts of the plot and the surrounding forest, and it is observed when the time has come for the land to rest. Just as the land has its time, seeds also have their planting cycles, which depend on the climatic characteristics throughout the year. Since agriculture is seasonal, certain seeds are sown during the rainy months. From January to May are the rainy months, called *ka'nija'* in Maya, and from May to September is another rainy season, called *ja' aja'al* in Maya. The Maya culture developed its own planting calendar, called *cabañuelas*, which is based on observing each day of January to forecast the weather for the entire year. Some still preserve and transmit this knowledge. This knowledge is used to plan or schedule planting. Ancient peoples possessed the greatest knowledge in this regard. They knew how to observe and identify what was happening or would happen in nature. When the first thunder, hail, or hailstorm of the season approached, they observed the sky, the cloud formations and their color, and alerted their families so they could protect the crops and some fruit trees. In Mayan culture, many of their actions were related to the observation of cause and effect; this is reflected in the fact that each city had astronomical observatories.

## 4.10 Metaphysical

Just as the relationship between human beings and nature is inseparable, so too is the connection with the metaphysical, that is, with beliefs: gods, deities, lords, and God (Christian, Catholic), and with rituals of protection and gratitude. In this context, it is observed that the activities of men and women are very different. Men are mostly more active, working in the cornfields and the forest from 5:00 a.m. until midday, while women work in agriculture in the backyards of their homes. Both men and women inhabit the backyards, the cornfields, and the forest; these are their primary spheres of influence. In recent years, women have had greater participation in all these spaces. Men identify with the lords of the forest: the gods of wind and rain, as well as with their guardians, such as the *aluxes* (mythical Mayan creatures). The men in these communities are ejido members and possess a portion of land, which is cared for by the lords of the forest and the cornfields. Those who are not

part of the territory and do not have the lord's permission are attacked by the caretakers. People from outside the territory can access these spaces accompanied by a lord. A fundamental aspect of respecting nature and caring for everything around us is understanding the existence of supreme beings who have provided everything within our reach.

## 4.11 The Role of Women

The activities on the *Solar* are labour-intensive and rely heavily on local family knowledge; they require hard work, dedication, observation, patience, and care. While the work of men and the entire family is important, women spend the most time on Solar agriculture.

Among the activities women undertake on the Solar, considering the territory they live in, women are the ones who spend the most time on the Solar. Their main role is being mothers and dedicating themselves to daily household chores. They take care of the family and maintain the Solar's spaces in harmony. In the production processes, they choose the planting sites and methods with the help of other family members, using the knowledge inherited from relatives. They select what they want to plant and how to do it. Some women prefer more ornamental plants than vegetables and fruit trees, while others opt for a mix of different plants.

The perception of life in the fields involves constantly observing the development and growth of the plants. This task is performed daily, in the morning and afternoon. Watering is more than just pouring water; it means observing each plant, its leaves, stems, flowers, fruit, and potential pests, so this activity is not always delegated. Family members understand the importance of giving thanks for what they receive, both men with respect to the Milpa and women for their work with their hands and the sweat of their brows at the Solar. Thus, they are clear that they must give back for what they have every day.

Among the women's complementary activities while living within the Solar is preparing food based on recipes learned from family members. Another aspect is the location of the village, which is relatively close to the state's main archaeological sites and tourist attractions, and its proximity to Quintana Roo. They divide their productive activities within the Solar with the production of handicrafts based on wood carving as a suitable aid for their husbands and young adult children. The embroidery of suits, *hipiles*, blouses, and accessories; the raising of chickens, turkeys, hairless pigs, and backyard pigs. Their activities have extended to the *Milpa* (maize-fields) and the mountains, where they plant and harvest firewood.

## 4.12 Conclusion

Agriculture in Mayan communities exemplifies living in harmony with and respecting nature. Considering the intense work in the cities, lifestyles, and the perfection and standardization of our surroundings, it seems that in rural life, time seems to stand still, and everything moves very slowly; the development path still feels far away. However, perceptions of life differ, and the same is true for the agricultural process. Agriculture is a process that takes time, with each seed having its season for planting, but the land must also be naturally prepared: the dry season, the rainy season, the phases of the moon, times to ask permission, times to give thanks, and times to rest. When the land is healthy, people can eat.

Agriculture can only be sustainable when its primary objective is simply to meet the basic need for hunger, as seen in communities. When the focus shifts to economic profitability aimed at making production processes more efficient—often at the expense of human and natural factors, particularly land as a primary resource—sustainable agriculture becomes a utopian idea.

The desire of some economies to transform every piece of land into a highly productive and profitable industry to meet global standards has resulted in significant pollution of natural resources, new diseases, and large industries studying these new illnesses. This industrial activity, in recent years, has failed to reduce poverty but has instead increased the waste of vast quantities of food. This suggests that agribusiness is not the solution to reducing hunger, but rather to high levels of pollution.

Unfortunately, in recent years, the Mayan population has been declining, the elders are being left behind, and the Mayan language and ancestral knowledge face the colonization of basic education in Spanish, resulting in their loss. The few remaining Mayan farmers lament the loss of soil health and the lack of water. It is at this point that the State must intervene decisively against the extractive industry. A policy lacking a social vision and with complete openness to the extractive industry leads to a significant loss of local identity, pollution, and destruction of biodiversity. A social perspective considers that the collateral damage caused by the industry outweighs the monetary benefits or economic spillover it brings to society, putting health and natural resources at risk in the long term, as in the case of the Maya, with their high levels of water pollution.

## References

Altieri, M. A. (2001). Principios de la agroecología. In *Agroecología: Principios y estrategias para diseñar sistemas agrarios sustentables* (pp. 27–34). Ediciones Científicas Americanas.

Bellon, M. R. (2014). Agrobiodiversity and agricultural development. *Outlooks on Pest Management, 25*(6), 281–285.

Fanon, F. (1961). *Los condenados de la tierra* (M. Vázquez Gómez, Trad.). Fondo de Cultura Económica.

Food and Agriculture Organization of the United Nations (FAO). (2006). *Seguridad alimentaria: Informe de política*. https://www.fao.org

Food and Agriculture Organization of the United Nations (FAO). (2011). Global food losses and food waste—Extent, causes and prevention. : FAO. Recuperado de https://www.fao.org/4/mb060e/mb060e00.htm

Food and Agriculture Organization of the United Nations (FAO). (2023). *¿Qué hace la FAO?* https://www.fao.org/about/what-we-do/es/

Hernández, M. (1999). *¿Hay una filosofía Bats'ivinik (tsotsil)? (Tesis de licenciatura)*. Universidad Nacional Autónoma de México. http://132.248.9.195/pd1999/279900/Index.html

Hernández, M. (2009). La filosofía maya. In E. Dussel, E. Mendieta, & C. Bohórquez (Eds.), *El pensamiento filosófico latinoamericano, del Caribe y latino 1300–2000*. Siglo XXI.

Hernández Solano, A., Dyer, G. A., Camacho Villa, T. C., Sulser, T., Becerril García, J., Burrola Méndez, S. I., Sonder, K., Meza Pale, P., Zepeda Villarreal, A., Ancira Moreno, M. M., Ramírez Silva, C. I., Rendón Medel, R., & Serratos Hernández, J. A. (2021). *Reporte técnico final del Proyecto TEEB AgriFood Maíz-Milpa. Tomo II: Análisis y escenarios de política pública para el sector maíz y milpa en México.*

Lenkersdorf, C. (2005). *Filosofar en clave tojolabal*. Miguel Ángel Porrúa.

Lugones, M. (2008). The coloniality of gender. *Worlds & Knowledges Otherwise*, Spring, 1–17. Duke University.

Maldonado-Torres, N. (2007). On the coloniality of being: Contributions to the development of a concept. *Cultural Studies, 21*(2–3), 240–270. https://doi.org/10.1080/09502380601162548

Mariaca, R. (2012). La complejidad del huerto familiar maya del sureste de México. In *El huerto familiar del sureste de México*. Secretaría de Recursos Naturales y Protección Ambiental del Estado de Tabasco; El Colegio de la Frontera Sur.

Mariaca, R., González, A., & Arias, L. (2010). *El huerto maya en el siglo XVI*. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación; Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias.

Martínez Isidro, P. (2022). *El pensamiento filosófico del pueblo maya sobre los procesos productivos del solar (Tesis doctoral)*. Universidad Autónoma de Yucatán.

Martínez, P. (2020). El solar maya a través de los cambios estructurales de la economía mexicana. *Revista del Centro de Graduados e Investigación, 35*(86), 41–49.

Mignolo, W. (2010). *Desobediencia epistémica: Retórica de la modernidad, lógica de la colonialidad y gramática de la descolonialidad*. Ediciones del Signo; Center for Global Studies and the Humanities, Duke University.

Pérez, M. (2012). Las metodologías horizontales. In M. Pérez & S. Sartorello (Coords.), *Horizontalidad, diálogo y reciprocidad en los métodos de investigación social y cultural* (pp. 11–14). Centro de Estudios Sociales y Jurídicos Mispat; Universidad Autónoma de Chiapas; Universidad Autónoma de San Luis Potosí; Consejo de Ciencia y Tecnología del Estado de Chiapas; Educación para las Ciencias en Chiapas.

Quijano, A. (2000). Colonialidad del poder, eurocentrismo y América Latina. In E. Lander (Comp.), *La colonialidad del saber: Eurocentrismo y ciencias sociales. Perspectivas latinoamericanas* (pp. 201–246). CLACSO; UNESCO.

Sánchez, A. (2019). El patrimonio inmaterial ligado al territorio, la pérdida más grave e invisible por el "tren maya". *Múuch' Xíinbal*. https://asambleamaya.wixsite.com/muuchxiinbal/single-post/2019/06/06/el-patrimonio-inmaterial-ligado-al-territorio-la-p%C3%A9rdida-m%C3%A1s-grave-e-invisible-por-el-tr

Sánchez, A., Cervera, M., Victoria, J., & Castillo, M. (2021). *Amarrando los saberes: Resiliencia en el habitar la casa y el territorio maya*. Casa Editorial UADY.

Schettini, P., & Cortazzo, I. (2015). *Análisis de datos cualitativos en la investigación social: Procedimientos y herramientas para la interpretación de información cualitativa*. Universidad de La Plata.

Shiva, V. (2000). *Staying alive: Women, ecology and development* (2ª ed.). Zed Books.

Sousa Santos, B. d. (2014). *Epistemologies of the South: Justice against epistemicide*. Routledge.

Strauss, A., & Corbin, J. (2002). *Bases de la investigación cualitativa: Técnicas y procedimientos para desarrollar la teoría fundamentada*. Universidad de Antioquia.

Tuck, E., & Yang, K. W. (2012). Decolonization is not a metaphor. *Decolonization: Indigeneity, Education & Society, 1*(1), 1–40.

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# Chapter 5
# The Maya Milpa: A Biocultural Regulatory Environmental Service That Conserves the Dry Forest of Yucatán "In Situ"

**Eduardo Adolfo Batllori Sampedro**

**Abstract** This chapter examines the milpa agroforestry practice in Yucatán, emphasizing its role in conserving biodiversity and supporting local livelihoods. Utilizing ancestral methods, the milpa fosters agrobiodiversity and sustainable land use, resisting capitalist exploitation while providing essential resources and maintaining ecological integrity within the region's dry forest ecosystems.

**Keywords** Milpa · Agroforestry · Biodiversity · Sustainability · Yucatán

## 5.1 Introduction

This chapter seeks to address the question of what types of practices persist and emerge in the context of a capitalist exploitation of land, nature, water, and people, which resist political integration (in terms of scales) and manage to re-elaborate alternative ancestral practices.

The milpa is a family agroforestry practice prevalent throughout Mesoamerica, especially in the Yucatán Peninsula, closely associated with indigenous peoples (Boege Schmidt, 2008) who depend heavily on their natural environment. The agricultural model, known as Ich Kool, employs the slash-and-burn technique and is accompanied by a household garden and various extractive practices. These practices provide essential resources such as animal protein, honey, construction materials, housing, medicinal plants, and firewood, which can account for over 27% of the gross value of production. The milpa practice enables the local population to self-employ and secure the necessary inputs for their family unit to thrive and reproduce. Maize is the central crop, accompanied by squash and beans, alongside additional crops like chilli and tomatoes (Becerril, 2014; Hernández Xolocotzi et al., 1995; Montiel et al., 1999; Rosales González & Cervera Arce, 2020; Terán & Rasmussen, 1992; Zizumbo et al., 1992). This practice fosters a broad range of agrobiodiversity.

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The cultivation and management of native maize by indigenous communities are considered a public service that conserves genetic diversity in situ and allows for its continuous evolution, the inherent capital of this germplasm from an ancient practice (Hernández Solano et al., 2021).

Among other relevant sectors based on the gross production value at 2013 prices, trade in goods stands out, in order of importance, contributing 37% to the gross production value. In third place is migratory activity, which sends remittances to family members in rural areas of southern Yucatán, accounting for 21% (Becerril, 2014).

Priority objectives of use are recognized, as well as the different productive processes carried out within each agro-habitat during their consecutive phases, which are distinguished by the number of years of fallow or vegetation regeneration. In the Ek lu'um agro-habitat, characterized by k'ankab or black soils on flat terrain, most productive activities take place, since the even relief facilitates physical work and provides the deepest, most fertile soils with the greatest moisture retention. Depending on the phase, different types of use are undertaken—such as forage and short-cycle crops like milpa, or Pach'pakal and Ch'akbipach during the shorter phases. In the intermediate phases, materials for construction and tool-making are gathered, while the longer phases yield building materials, fuel, beekeeping resources, and home gardens (solar).

The predominant cycle across the territory is the annual one, which generally consists of a dry season (from November to April) and a rainy season (from May to October). This seasonal rhythm is further marked by fluctuations caused by the northern cold fronts, occurring between October and April, when temperature and winter rainfall vary significantly. The rhythm is complemented by the canícula—a mid-summer drought during the rainy season—when rainfall may decrease drastically in July and August. Accompanying these seasonal patterns, from February to May, are forest fires and agricultural burnings. Another cycle, known as the hyperannual cycle, reveals climatic variations lasting between 9 and 11 years, most frequently every 10 years, during which wet and dry years alternate. Within these hyperannual cycles, distinct patterns of intense droughts or hurricanes—typically from June to October—can be observed (Arias, 1995; López et al., 2018).

The central philosophy of the Maya milpa biocultural practice is grounded in the belief that nature is sacred—an entity that does not belong to humankind and possesses a power greater than that of humans. Therefore, its use and benefits are to be requested and thanked for, and exploitation must remain moderate. This principle has been key to the long-term sustainability of the system.

Each Indigenous community expresses its cultural identity through ceremonies, dances, handicrafts, and religious rituals that embody deeply symbolic traditions. Alongside agricultural practices, farmers perform a series of supra-organic rituals to ask or give thanks to the divine protectors of maize, which play a central role in the Yucatec peasant's cosmogony. There are several ceremonies associated with the milpa, including those of supplication, gratitude, and permission. Among the most notable are the Ch'a chaak, Hanlil k'ool, Tsa saka', and Hooché, in all of which maize is the principal element, both as an offering and as nourishment. Their

empirical knowledge is also remarkable, particularly their methods and techniques for healing with medicinal plants, their holistic vision and respect for nature, and their forms of productive organisation.

Nuclear and extended families within the communities have traditionally been responsible for sustaining the milpa's biocultural practice. The family's biosocial ties provide it with great strength, flexibility, and adaptive capacity. The community has been the social framework within which milpero families develop. It has traditionally held strong internal cohesion due to the existence of kinship and solidarity bonds that foster mutual support. The family base and the collective use of land—imposed by the roza, tumba y quema (slash-and-burn) system—have strengthened communal ties and encouraged the exchange of goods and seeds.

When the milpa begins to produce less, it is left uncultivated for a time to allow the soil to regain its fertility through the growth of secondary vegetation. While a new milpa is being cleared and burned, a cyclical pattern is established that can cover an area of approximately 80–120 ha (over the average lifespan of a milpa producer), although only a small portion is actively cultivated at any given time (Illsley Granich, 1995; Sanabria, 1986). This practice results in high environmental heterogeneity. This activity has formed and continues to form the basis of subsistence for agricultural settlements from ancient times to the present, representing over 5000 years of sustained use.

The value of a product is determined by the producers themselves, a concept referred to as "shadow price." For many milperos, this shadow price is significantly higher than the market price of maize (Hernández Solano et al., 2021). By establishing this shadow price, milperos contribute to the environmental service of regulating biodiversity in forests and jungles through ancestral agroforestry and agroecological practices.

## 5.2 The Biocultural Practice of the Milpa and the Legal Framework Governing Access to Natural Resources

Based on the analysis of the legal framework that regulates access to natural resources and promotes investment in the rural sector, it is evident that there are currently no viable conditions for this traditional practice to be carried out adequately. Within the regulatory analysis, it is observed that the governmental support once provided by the former Secretariat of Livestock, Agriculture, Rural Development and Fisheries (SAGARPA), within the framework of the *Ley de Desarrollo Rural Sustentable* (Sustainable Rural Development Law), the *Programa Especial Concurrente* (Special Concurrent Programme), and the *Reglas de Operación* (Operating Rules) for implementing support from the Agro-Productive Programme, promoted only the production of improved maize varieties as a monoculture, and occasionally the associated cultivation of beans.

At present, the new Secretariat of Agriculture and Rural Development (SADER) has begun to promote actions aimed at strengthening agroecological and polyculture production systems, such as *milpa* and coffee cultivation, through the *Programa Sembrando Vida* (Sowing Life Programme). Although both the *Ley de Desarrollo Rural Sustentable* and the *Programa Especial Concurrente* seek comprehensive rural development through the participation of various institutions, in practice their joint implementation is almost non-existent. This has resulted in the intensive use of land, with little fallow or resting time for the forest, and consequently a gradual loss of soil fertility. As a result, the use of chemical fertilisers has become more frequent and abundant; likewise, the use of pesticides and herbicides (included in the technological packages offered by government support) has led to soil and water pollution, loss of biodiversity, and adverse effects on the health of producers (Becerril, 2014; Villanueva, 2002).

On the other hand, the by-products obtained from the agronomic biocultural activities of the Maya communities—particularly those related to timber and non-timber forest resources (such as firewood, charcoal, logs, and *huano* palm leaves for housing construction)—are regulated by the *Ley de Desarrollo Forestal Sustentable* (Sustainable Forestry Development Law), both at the federal and state levels. Therefore, their use requires forest permits derived from approved Forest Management Programmes and Environmental Impact Statements as stipulated in the *Ley General de Equilibrio Ecológico y Protección al Ambiente* (General Law of Ecological Balance and Environmental Protection).

Due to this regulatory framework, the integral use of the *milpa* and its by-products may lead to producers being stopped by authorities—whether inspectors from the *Procuraduría Federal de Protección al Ambiente* (PROFEPA) or municipal, state, or federal police—during transport, and subjected to administrative or criminal proceedings, or in some cases, extortion in exchange for allowing passage. Regarding firewood specifically, the *Norma Oficial Mexicana* NOM-012-SEMARNAT-1996 establishes the procedures, criteria, and specifications for the use, transport, and storage of firewood for domestic purposes. According to Article 7, Section XLIV, of the *Ley de Desarrollo Forestal Sustentable del Estado de Yucatán* (Yucatán State Sustainable Forestry Development Law), "domestic use" is defined as "*The non-commercial use of forest resources extracted from their natural environment for ritual purposes, or to meet needs for heating, housing, farming tools, and other basic requirements in rural areas*."

The same situation applies to other by-products such as forest soil (*NOM-027-SEMARNAT-1996*), roots and rhizomes (*NOM-038-SEMARNAT-1995*), bark, stems, and whole plants (*NOM-005-SEMARNAT-1997*), palm leaves (*NOM-006-SEMARNAT-1997*), branches, leaves, or fronds, flowers, fruits, and seeds (*NOM-007-SEMARNAT-1997*), buds (*NOM-008-SEMARNAT-1996*), and materials such as bamboo, wicker, liana, rattan, cane, reed, and raffia used in basketry (*NOM-029-SEMARNAT-2003*), among others—many of which are used in traditional Maya herbal medicine. None of these, however, are available in the Maya language.

With regard to charcoal, it is also regulated under Article 41 of the *Ley de Prevención y Combate de Incendios del Estado de Yucatán* (Yucatán State Law on

Fire Prevention and Control), concerning the installation of kilns for charcoal production. Federal forestry authorities have been questioned about whether timber and non-timber forest by-products derived from agricultural activities—subsidised through programs such as *PROAGRO-Productivo* or *Sembrando Vida*—should be classified as special management waste resulting from such activities, as established in Article 19, Section III, of the *Ley General para la Prevención y Gestión Integral de los Residuos* (General Law for the Prevention and Integral Management of Waste), as well as Article 6, Section C, of the *Ley para la Gestión Integral de los Residuos en el Estado de Yucatán* (Yucatán State Law for the Integral Management of Waste). Accordingly, the regulation of their proper management should fall under state jurisdiction through a Waste Management Programme derived from agricultural activity. However, inter-institutional agreements have not been reached, forcing producers to opt for forestry specialisation, which entails numerous administrative procedures, requirements, and associated costs.

Regarding wildlife—particularly fauna—which is also a by-product of the *milpa* (such as deer and wild turkeys, among others), it is regulated by the *Ley General de Vida Silvestre* (General Wildlife Law). Its use requires authorisation from the *Secretaría de Medio Ambiente y Recursos Naturales* (SEMARNAT). Although the law allows for subsistence use (Article 92) and stipulates that producers will receive support, technical advice, and training from the competent authorities, and that associations will be promoted for such purposes, in practice this rarely occurs. Producers are often detained while transporting animals or animal parts. Furthermore, the lists determining the practices and permissible quantities of wildlife specimens, parts, and derivatives for traditional ceremonies and rituals in rural communities—as required by Article 93 of the same law—have not been issued. In any case, the federal authority provides for the establishment of *Unidades de Manejo para la Conservación de Vida Silvestre* (UMAs, Wildlife Management Units), which require specialised studies included in a Management Plan to be registered with SEMARNAT in order to obtain harvest quotas.

The extraction of stones, *sahcab* (a type of calcareous material), and the construction of kilns for lime production are regulated by the *Ley de Protección al Medio Ambiente del Estado de Yucatán* (Yucatán State Environmental Protection Law), which requires environmental impact assessments by the state authority, as well as land-use permits issued by the municipal authority. Lime production is also regulated under Article 41 of the *Ley de Prevención y Combate de Incendios del Estado de Yucatán*. These restrictions further limit the possibilities for the comprehensive use of available resources by Maya communities for housing improvement and other purposes. The situations described above demonstrate the multiple constraints on the use and access to the natural resources of the *milpa* and the surrounding forest by Maya farmers.

## 5.3 Trends in Ecosystem Services

In the state of Yucatán, trends in ecosystem services across various management units of the POETY (2007) indicate that the jungle landscapes prevailing in the region are best maintained over time and in the best conditions under biocultural management practices, particularly in the dry forests through milpa. This is especially true in the upper- and mid-sections of the hydrographic basins, where any alteration or degradation can affect the entire basin and the associated fluvial-marine system (Batllori Sampedro, 2015). It also shows a particularly favoured area within the geohydrological zone of the cenote ring, due to the recovery of the low deciduous forest and habitats of many species following the abandonment of henequen monoculture in the early 1980s.

All of the above highlights the need to develop strategies to ensure the long-term maintenance or improvement of these ecosystem services vital for human well-being. One such strategy is the proposal, officially recognized by the Food and Agriculture Organization (FAO) in 2023, to designate the Ich Kool Maya Milpa as a Globally Important Agricultural Heritage System (GIAHS) (Terán Contreras, 2022).

The ancestral and current practices of the Maya indigenous community are recognized for their role in ensuring the "in situ" conservation of the dry forest in the peninsula. This recognition extends to the constitutional recognition of the Maya indigenous community by the state of Yucatán as public law subjects, therefore granting them the right to manage their preferential natural resources (Judicial Weekly of the Federation and its Gazette Volume: XVI, November 2002. Thesis: 2a. CXXXVIII/2002 Page: 445 Subject: Constitutional Isolated Thesis). This legal framework provides a biocultural regulatory service for the forest, which is also regulated by bioclimatic processes.

However, the legal provisions regulating access to natural resources are implemented thematically and sectorally, establishing specific requirements and authorizations for each aspect essential to the survival of the Maya peasant family, such as food, housing, energy, and health. As a result, the comprehensive and diversified use of the habitat is challenging to implement, affecting the effectiveness of the environmental regulatory service.

The situation creates a perception of environmental offender, leading to a reliance on monospecific production through official support programs. This entraps the Maya producer in a cycle that impoverishes not only the plant diversity of the forest, the fertility of its soils, and the wildlife, but also drives the farmers into a state of asset poverty, capacity poverty, and food insecurity.

Ultimately, they are forced to sell their lands and migrate to other places, such as large cities like Mérida or the Riviera Maya in Quintana Roo, where they often work as low-wage labourers in the construction industry. Some even migrate abroad, particularly to the United States, sending remittances to supplement their families' income (Becerril, 2014). This cycle anchors them in a state of economic and social dependency. This issue is closely tied to Human Rights and Indigenous Rights (Batllori Sampedro, 2023; Quintal López, 2014).

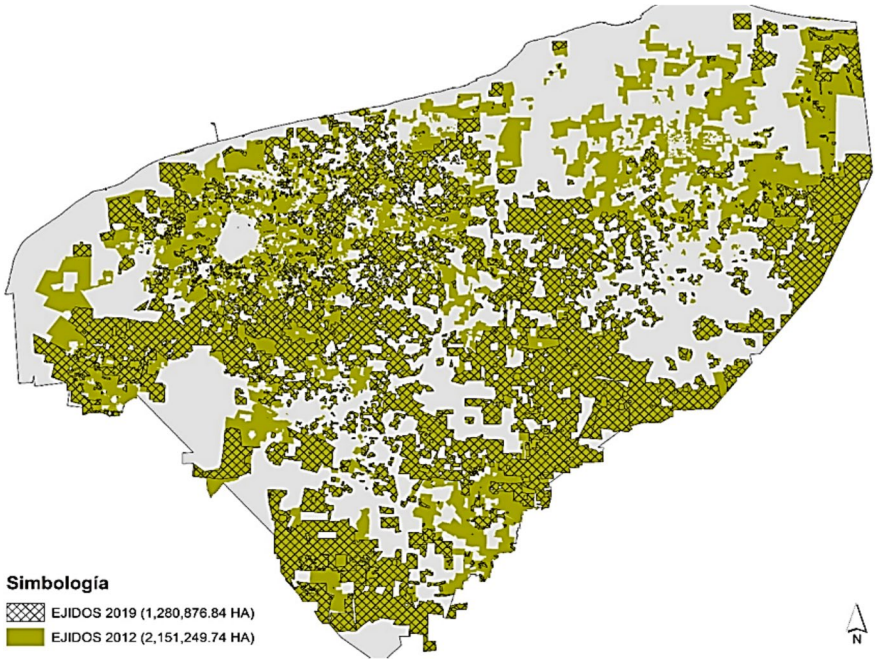



**Fig. 5.1** Variation in ejidal surface area in the State of Yucatán from 2012 to 2019. Source: Prepared by the author using data from the RAN 2019. The map was produced using Geographic Information Systems (GIS), employing ArcMap version 10.8 under a trial licence provided by Esri. This arrangement allowed temporary access to the software's tools for the integration, analysis, and representation of spatial information

There is a significant annual loss of common-use ejidal land, totalling 124,338.90 ha, with an annual loss rate of 5.8%. From 2012 to 2019, the cumulative loss amounted to 870,372.90 ha (as shown in mottled green in Fig. 5.1), according to the National Agrarian Registry (RAN, 2012–2019). This represents severe erosion of the agro-habitat, putting this biocultural system at risk of fragmentation and further erosion.

This biocultural system, which has evolved with its germplasm over the past 5000 years through a resilient and adaptive process, shows a concerning trend towards decreasing precipitation and increasing temperatures, which will displace medium subdeciduous and low deciduous forests with spiny low deciduous forests featuring cacti, resulting in a warm and dry climate. According to Becerril (2014), one of the significant rent challenges families face in milpa communities is the high economic vulnerability, with 50% of milpa households failing to meet the minimum welfare line. However, milpas remain a viable option for ensuring food diversity for the family (as 55% of the value of the milpa comes from associated crops and not just maize).

Currently, we are experiencing a dangerous erosion of genetic biodiversity, largely due to the replacement of traditional seeds with improved seeds and

mechanized, transgenic agricultural systems that are not necessarily more profitable. This situation is compounded by cultural erosion caused by a lack of generational transition and the migration of young people. Additionally, we are also contending with the effects of climate change in the region.

Climate change can further exacerbate biocultural erosion by restricting access to the preferential natural resources of indigenous communities. It may also affect the availability and quality of water, hydraulic infrastructure, and the governance capacity related to water resources, impacting the health of the population, family production methods due to flooding and droughts, and the health of continental and coastal ecosystems (Canul-Macario, 2020; PHR-PY, 2020–2024; Rodríguez-Huerta et al., 2020).

The anticipated risks associated with climate change are as follows:

(a) A decrease in water availability resulting from expected changes in precipitation and temperature in the region, leading to an increase in droughts.
(b) Salinization of the aquifer due to rising sea levels and the elevation of the saline interface.
(c) An increase in flooding as a result of more intense storms and hurricanes.
(d) Other risks such as an increase in vector-borne diseases, contamination from agrochemicals, and a decline in agricultural yields.

The coastal aquifers of the Yucatán Peninsula are particularly vulnerable to saltwater intrusion, primarily due to their high permeability and low hydraulic gradient (Canul-Macario, 2020). Since 2015, the Yucatán Peninsula and Cozumel Island aquifers have been identified as at risk for saltwater intrusion (PHR-PY, 2020–2024). As sea levels rise, hurricane intensity increases, droughts become more frequent, and groundwater levels decline, this issue will worsen, jeopardizing access to potable water in coastal areas of the Yucatán Peninsula. By 2060, it may no longer be possible to find potable groundwater (with a salinity of less than 5 g/l) up to 15 km inland from the coast in some areas of Yucatán.

On average, a decrease in precipitation of 39.4 mm/year is estimated in the Yucatán Peninsula, along with a projected increase in temperatures. This temperature rise will lead to a heightened potential for evapotranspiration (PHR-PY, 2020–2024). The combination of these two expected effects has the potential to generate a 48.7% decrease in aquifer recharge in the Yucatán Peninsula by 2050, which will affect water availability for various human uses. Additionally, the Yucatán Peninsula's population is projected to increase by 36% by 2050 compared to 2020 (CONAPO, 2018). However, due to demographic changes from the Maya Train project, a larger increase of 64% is estimated for the same period based on data from UN-Habitat (2019).

The direct effect of insufficient rainfall and reduced water supply during droughts poses risks to the biocultural system. It is important to reduce the vulnerability of the population (particularly among indigenous and marginalized communities) due to crop losses, seed damage, and beehive destruction caused by flooding from hurricanes and storms, which are expected to become more intense due to climate change. The Planning Unit of the Basin Council with the highest underserved rural

population is located in Northern Yucatán, within the geohydrological zone of the cenote ring, accounting for 22% of the total peninsula. Access to potable water during and after extreme events is also at risk due to potential damage to drinking water and treatment plants and wells, power outages, and contamination of the aquifer from runoff and sewage overflow.

In light of the above, it is important to promote the Dynamic Conservation Plan recognized by the FAO of the Ich Kool Milpa Maya Peninsula as a System of Innovative Agricultural Practices (SIPAM). This plan aims to support the establishment of the Milpero Council, encourages the formation of the Academic Council, and promotes the installation of the Intersecretarial Council to operate a special concurrent programme for the state and peninsula Milpera region (Government of the State of Yucatán, 2018). In particular, Item 8 of the Specific Objectives of the Dynamic Action Plan of the SIPAM Ich Kool, Milpa Maya Peninsula, aims to enhance institutional coordination in policies that promote milpa agriculture and adjust regulations to align with the requirements and agro-cultural practices of the milpa. The following lines of action are proposed:

(a) Raise awareness among governmental institutions about the integrity of the milpa system. This aims to ensure that milperos are no longer criminalized for using the by-products from milpa processes—such as clearing, burning, and harvesting—like firewood, timber for construction, charcoal, and wild animals, which are used for family and community purposes.
(b) Foster coordination among the regulations of PROFEPA, CONAFOR, SEMARNAT, state governments, etc., to promote milpa and prevent the criminalization of milperos.

## References

Arias Reyes, L. (1995). La producción milpera actual en Yaxcabá, Yucatán. In E. Hernández Xolocotzi, E. Bello Baltazar & L. Levy Tacher (Comps.), *La milpa en Yucatán: Un sistema de producción agrícola tradicional* (Tomo 1,cap. 8, p. 181). Colegio de Postgraduados, Universidad Autónoma Chapingo.

Batllori Sampedro, E. (2015). *Servicios de los ecosistemas para el bienestar humano*. Secretaría de Desarrollo Urbano y Medio Ambiente, Gobierno del Estado de Yucatán.

Batllori Sampedro, E. A. (2023). La práctica biocultural de la milpa maya y los derechos humanos en Yucatán. *Revista Latinoamericana de Derechos Humanos, 34*(2). https://doi.org/10.15359/rldh

Becerril, J. (2014). *Elaboración de la matriz de contabilidad social para la evaluación socioeconómica en la Reserva Estatal Biocultural del Puuc: Reporte final de investigación* (pp. 17, 38, 47, 67). Facultad de Economía, Universidad Autónoma de Yucatán; The Nature Conservancy; Junta Intermunicipal Biocultural del Puuc; Secretaría de Desarrollo Urbano y Medio Ambiente del Estado de Yucatán.

Boege Schmidt, E. (2008). *El patrimonio biocultural de los pueblos indígenas de México*. Instituto Nacional de Antropología e Historia; Comisión Nacional para el Desarrollo de los Pueblos Indígenas.

Canul-Macario, C. (2020). *Dinámica de la interfase salina del acuífero de la costa noroeste de Yucatán y escenarios frente al incremento del nivel medio del mar* (p. 165). http://132.248.9.195/ptd2020/octubre/0804218/Index.html

Congreso del Estado de Yucatán. (2017). *Ley para la Protección de los Derechos de la Comunidad Maya del Estado de Yucatán* [última reforma publicada en el Diario Oficial del Estado, D.O. No. 407, el 31 de octubre de 2017]. Secretaría General del Poder Legislativo, Unidad de Servicios Técnico-Legislativos.

Congreso del Estado de Yucatán. (2019). *Ley de Prevención y Combate de Incendios Agropecuarios y Forestales del Estado de Yucatán* [última reforma publicada en el Diario Oficial del Estado el 31 de julio de 2019, D.O. No. 718]. Secretaría General del Poder Legislativo, Unidad de Servicios Técnico-Legislativos.

Congreso del Estado de Yucatán. (2021a). *Ley para la Gestión Integral de los Residuos en el Estado de Yucatán* [última reforma publicada en el Diario Oficial del Estado, D.O. No. 396, el 4 de enero de 2021]. Secretaría General del Poder Legislativo, Unidad de Servicios Técnico-Legislativos.

Congreso del Estado de Yucatán. (2021b). *Ley de Protección al Medio Ambiente del Estado de Yucatán* [última reforma publicada en el Diario Oficial del Estado el 4 de enero de 2021]. Secretaría General del Poder Legislativo, Unidad de Servicios Técnico-Legislativos.

Consejo Nacional de Población (CONAPO). (2018). *Proyecciones poblacionales por entidad federativa*. Secretaría de Gobierno de la República Mexicana.

Gobierno del Estado de Yucatán. (2018). Decreto por el que se aprueba y ordena la publicación del programa especial de la región milpera maya y área de influencia del estado de yucatán. Decreto 621/2018. *Diario Oficial del Estado*, 22 de junio de 2018.

Hernández Solano, A., Dyer, G. A., Camacho Villa, T. C., Sulser, T., Becerril García, J., Burrola Méndez, S. I., Sonder, K., Meza Pale, P., Zepeda Villareal, A., Ancira Moreno, M. M., Ramírez Silva, C. I., Rendón Medel, R., & Serratos Hernández, J. A. (2021). *Reporte técnico final del proyecto TEEB AgriFood Maíz-Milpa: Tomo I. Proyección business-as-usual (BAU) del sector maíz y milpa en México en el contexto del cambio climático* (pp. 33, 35). Universidad Iberoamericana.

Hernández Xolocotzi, E., Levy Tacher, L., & Bello Baltazar, E. (1995). La rosa-tumba-quema en Yucatán: Aspectos ecológicos de Yucatán. In E. Hernández Xolocotzi, E. Bello Baltazar, & L. Levy Tacher (Comps.), *La milpa en Yucatán: Un sistema de producción agrícola tradicional* (Tomo 1, cap. 2, pp. 76–77). Colegio de Postgraduados.

Illsley Granich, C. (1995). Vegetación y milpa en el ejido de Yaxcabá, Yucatán. In E. Hernández Xolocotzi, E. Bello Baltazar, & L. Levy Tacher (Comps.), *La milpa en Yucatán: Un sistema de producción agrícola tradicional* (Tomo 1, cap. 6, p. 129). Colegio de Postgraduados.

López, M., Hernández, F., & Becerril, J. (2018). El patrimonio biocultural maya-yucateco desde la perspectiva de la ecología política: el caso del huerto familiar en Chimay. *Journal of Political Ecology, 25*. Universidad Autónoma de Yucatán.

Montiel, S., Arias, L., & Dickinson, F. (1999). La cacería tradicional en el norte de Yucatán: Una práctica comunitaria. *Geografía Agrícola, 29*, 42–52. Universidad Autónoma de Chapingo.

POETY. (2007). *Programa de ordenamiento ecológico del territorio del Estado de Yucatán*. Decreto número 793.

Programa Hídrico Regional Península de Yucatán. (2020–2024). Secretaría de Medio Ambiente y Recursos Naturales; Comisión Nacional del Agua; Organismo de Cuenca Península de Yucatán.

Quintal López, R. (2014). *Primera etapa de la consulta para la identificación y el registro de las comunidades mayas del Estado de Yucatán*. Comisión Nacional para el Desarrollo de los Pueblos Indígenas; H. Congreso del Estado de Yucatán; Instituto para el Desarrollo de la Cultura Maya del Estado de Yucatán; Universidad Autónoma de Yucatán.

Registro Agrario Nacional. (2012–2019). Secretaría de Desarrollo Agrario, Territorial y Urbano.

Rodríguez-Huerta, E., Rosas-Casals, M., & Hernández-Terrones, L. M. (2020). A water balance model to estimate climate change impact on groundwater recharge in Yucatan Peninsula, Mexico. *Hydrological Sciences Journal, 65*(3), 470–486. https://doi.org/10.1080/02626667.2019.1702989

Rosales González, M., & Cervera Arce, G. (2020). *Nuestras semillas, nuestras milpas, nuestros pueblos* (p. 162). Instituto Nacional de Antropología e Historia; Misioneros A. C. ISBN: 978-607-539-487-9.

Sanabria, O. L. (1986). El uso y manejo forestal en la comunidad de Xul, en el sur de Yucatán. *Etnoflora Yucatanense*, (2), 35, 40, 84, 118. Instituto Nacional de Investigaciones sobre Recursos Bióticos (INIREB).

Terán, C. S., & Rasmussen, C. (1992). Estrategia agrícola y religión. In D. Zizumbo, C. Rasmussen, L. Arias, & S. Terán (Eds.), *La modernización de la milpa en Yucatán: Utopía o realidad* (p. 262) Centro de Investigación Científica de Yucatán; Ministerio de Relaciones Exteriores de Dinamarca (DANIDA).

Terán Contreras, S. (2022). *Proposal for the recognition of the peninsular Maya milpa as a globally important agricultural heritage system*. Secretaría de Desarrollo Sustentable de Yucatán.

Zizumbo, D., Rasmussen, C., Arias, L., & Terán, S. (1992). *La modernización de la milpa en Yucatán: Utopía o realidad*. Centro de Investigación Científica de Yucatán; Ministerio de Relaciones Exteriores de Dinamarca (DANIDA).

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# Chapter 6
# Analysis of the Floristic Richness of Home Gardens in the South-Southeast Region of Mexico

**Ramón Mariaca Méndez, Martha Gual Díaz, and Ana Luisa Figueroa Fernández**

**Abstract** Home gardens are among the most important agroecosystems in tropical and subtropical countries, including Mexico. They play a fundamental role in producing various goods through plant cultivation and animal husbandry. The present study analyzed the floristic richness of home gardens in south-southeast Mexico by organizing and synthesizing the existing floristic lists from 136 studies on the subject. This region comprises 25% of the national territory and is home to 45 Indigenous communities. The study estimated that there are approximately 1,760,031 home garden units, covering an estimated area of 105,602 ha. It identified a total of 1452 species, grouped into 822 genera and 164 botanical families. The botanical families with the highest species richness were Fabaceae with 149 species, followed by Asteraceae with 97, and Malvaceae with 67. In terms of plant form, trees comprised the highest percentage at 51.8% (800 species), while shrubs and herbs together made up 48.2% (743 species). Related to plant species origin, 56% (859 species) were native, 36.4% (529 species) were introduced, and 10.6% (155 species) were endemic. In terms of utilization, 374 species were catalogued as multipurpose. Additionally, 54.7% (794 species) were used for medicinal purposes, 51.4% (746 species) for food, 35.6% (517 species) for the construction of minor and major infrastructure, and 33.4% (485 species) as firewood. Notably, for 26 species, more than 100 local names were reported. According to national and international authorities, a total of 515 species were identified as being at risk of extinction. The study also addressed several gaps and errors found during the database creation due

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to specific details not being considered by some of the authors' researchers. The findings highlight the urgent need for the Mexican government, academic institutions, and non-governmental organizations to prioritize the study, conservation, and protection of home gardens, as these ecosystems play a fundamental role in the lives of rural families and local markets across the country.

**Keywords** Risk categories · Endemic · Floristic · Traditional family garden · Introduced · Native · Solar · Patio

## 6.1 Introduction

In the Mexican agricultural sector, there are three interconnected areas: (a) home gardens, located next to the home, where families cultivate plants and animals that hold value or serve a purpose for them; (b) agricultural plots ("milpas"), which incorporate agroforestry practices and provide a range of ecosystem, productive, economic and cultural benefits; and (c) natural ecosystems (forest, jungle, scrubland, etc.), from which families derive some of their resources. These natural ecosystems also supply plants and animals to the agroforestry systems, benefiting both home gardens and agricultural plots (Casas et al., 2017).

Home gardens are among the oldest agroecosystems in Mesoamerica and closely associated with the origins of agriculture (González-Jácome, 2007; MacNeish, 1967; Vandermarker, 2006). Their importance for maintaining and reproducing domestic groups has been highlighted in Mesoamerica since pre-Hispanic times. In the Yucatan Peninsula, which has been inhabited by the peninsular Mayan population for several millennia, records indicate the presence of fruit trees within domestic units during the Classic (600–900 AD) and Post-Classic (900–1500 AD) periods (Mariaca-Méndez et al., 2010).

Home gardens can be defined in several ways. Some definitions are simple, such as "it is an appropriate alternative for the family to produce and consume, at low cost, fresh and healthy products for a balanced diet" (SADER, 2023). Other definitions are more complex and incorporate additional elements: for example, "it is a socioecological system that highlights the biculturality of those who day by day build them in a given space, time and context" (Lope-Alzina et al., 2018).

The authors of this paper decided to include the following definition (Mariaca-Méndez, 2012):

> An agroecosystem with traditional roots, dynamic in time and space, which is inhabited by the family unit, and where the processes of selection, domestication, diversification and conservation are oriented towards the production and reproduction of flora and fauna and, sometimes, fungi. It is closely related to the conservation of natural resources, the social, economic and cultural conditions of the family, as well as the enrichment, generation and appropriation of technology. Additionally, the purpose of considering the family that inhabits within it, is because they delimit the shape, structure, diversity and richness of species, as well as the history and future of this form of production of goodies.

In Mexican academic literature, particularly from the south-southeast region of the country (which includes the states of Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatan), the general term used to refer to home gardens is "huerto familiar." However, during fieldwork conducted by the authors of this paper, several equivalent terms were discovered, including "*patio*" in Campeche, Veracruz, Chiapas, Tabasco, as well as throughout the Yucatan Peninsula; "*solar*" in Campeche, Chiapas, Oaxaca, Quintana Roo, Veracruz and Yucatan; "*traspatio*" in Veracruz and Yucatan; and "*jardines*" in the Costa Grande region of Guerrero.

Additionally, Mariaca-Méndez (2012) compiled a list of names given to this agroecosystem in Indigenous languages. Some examples from southeast Mexico include "patna" and "patchocona" among the Tsotsiles of the Highland Chiapas region; "patna" and "amak" among the Tseltales of the Highland and jungle region of Chiapas; "paty otoyoty" and "chumli'b" among the Ch'oles of northern Chiapas; "angojmo" among the Zoques of Pichucalco, Tabasco; and "tiotot" among the Chontales of Ocualtitán, Tabasco. Finally, among the Mayans of the Yucatan Peninsula, various terms are used such as "inn luumel" (my lot, my land, my plot), "pach nah" (what is in the surroundings of the home), "inn wotoch" (my house, my land), "ac tan'nah" (the front of the lot), "ix nah" (inside the home), and "*ta'an cab*" (outside the house). In international literature, particularly in English, the terms "home garden," "kitchen garden," and "backyard" are commonly found.

Many studies on home gardens primarily focus on plants, often neglecting husbandry of wild and domesticated fauna (Mariaca-Méndez, 2017). In terms of plant management within home gardens, it is common to find various sections that include ornamental and medicinal plants, vegetables, seedbeds, and nurseries, "milpa" (maize fields), a composting area, and spaces dedicated to animal husbandry, among others (Bermejo, 2015; Monroy & Colín, 2012; Ortiz-Sánchez et al., 2015; Quintero, 2015). The management of these gardens is closely associated with their floristic composition and structure. It is based on the knowledge of the biophysical environment, the market value of the products, cultural practices, and the experience of those managing the home garden (Colín et al., 2012). According to Quintero (2015), typically, the entire family is involved in the management of the home gardens; however, it is recognized that women tend to invest more time in this activity (developing a wide variety of activities), especially due to its proximity to the domestic sphere.

At an ecological level, this agroecosystem plays several environmental roles. The structure and arrangement of the plant species create microclimates. For example, trees provide shade and produce leaf litter, which contributes to nutrient recycling and helps maintain soil fertility. Shrubs and herbaceous plants, with their different light requirements, prevent soil erosion and increase water uptake through infiltration (Gutiérrez, 2003; Martínez & Juan-Pérez, 2005). Additionally, using tree species as fences to delimit the home garden promotes soil conservation White-Olascoaga et al., 2013)

Mariaca-Méndez (2012) highlights the importance of home gardens in various ecological, agroecological, social, and cultural contexts. These include protecting

the home from direct insolation and strong winds, thus creating a pleasant microenvironment; acting as a dynamic bank for animal, plant, fungal, and microbiological germplasm; functioning as a laboratory for plant and animal domestication; serving as a biological micro-corridor; providing a means of production for different goods and services for the family, mainly products with practical value; offering a way for families to generate savings and increase their economic resources; and creating a space where culture values are transmitted and the family unit is nurtured.

Home gardens have become a refuge for some wild plant species that are threatened or in danger of disappearing from their natural habitats (Bermejo, 2015). They are considered reservoirs for biodiversity conservation, as many species' germplasm is managed within these spaces (Pulido et al., 2008).

One of the most important features of home gardens is the high diversity of species cultivated and raised, especially in humid and sub-humid tropical climates. In many cases, home gardens can contain more than 100 plant species and between 10 and 20 animal species. According to Caballero et al. (2010), Mexico ranks among the top countries in terms of species diversity worldwide, following Southeast Asia, specifically Indonesia. The authors reported a total of 1400 species of vascular plants in Mexican home gardens, of which 537 are classified as herbaceous plants, 224 as shrubs, and 282 as trees.

Home gardens are considered as the richest agroecosystem in the world in terms of species diversity and, consequently, agrobiodiversity. However, fewer than 150 studies have been conducted on this subject in Mexico. This number is considered low, given the fact that the country is divided into 32 states, is home to 68 Indigenous peoples, and boasts a wide range of ecological conditions due to its highly variable orography, with altitudes ranging from sea level to 5600 m above sea level.

In Mexico, 14 biogeographic regions have been established based on climatic, geological, and biotic criteria, in accordance with the recognized ecoregions of the country. These include five provinces in the Nearctic region, four in the Neotropical region, and five in the Mexican Transition Zone (Morrone, 2019; Universidad Nacional Autónoma de México (UNAM), 2022).

Our observations indicate that rural and semi-rural home gardens supply goods to almost all urban markets, due to the great diversity of vegetables cultivated and animals raised there. They serve as an important complement to production from larger crop plantations and specialized farms, both nationally and internationally.

Mexico is considered one of the 17 megadiverse countries of the world due to the high cultural and biological diversity, as well as the large number of endemic species present (Mittermeier et al., 1997). According to the National Biodiversity Information System of the National Commission for the Knowledge and Use of Biodiversity of Mexico (Comisión Nacional para el Uso y Conocimiento de la Biodiversidad) (CONABIO, 2024), there are 1178 vertebrate species (specifically mammals), 46,254 invertebrate species, 61,765 plant species (vascular and non-vascular), and 6714 fungi species (lower and higher).

The extensive knowledge accumulated by the 68 Indigenous peoples of Mexico regarding the use, management, and conservation of biological resources is widely recognized, according to the National Institute of Indigenous Peoples of Mexico

(2020). As a result, Mexico ranks second in the world in terms of biculturality, following India, Australia, Zaire, and Brazil (Boege, 2008).

As a consequence, Mexico's agrobiodiversity holds considerable importance. Mesoamerica, originally defined by Kirchoff (1943) as a cultural region with particular features, encompasses a large proportion of Mexican territory. This area includes several warm and humid climates that are home to high levels of biological and cultural diversity. Here, various strategies for the appropriation of natural resources have evolved. One notable aspect of this region is its home gardens, which are distinguished by their high floristic diversity, multifunctionality, and close relationship with domestic groups (Eyzaguirre & Linares, 2004; Lope-Alzina et al., 2018).

In summary, we are dealing with a region of high biocultural diversity (Boege, 2008; Maffi, 2005; Toledo & Barrera-Bassols, 2008). This diversity is evident in the complex systems used for the management and domestication of landscapes, plants, animals, and microorganisms. Researchers of plant domestication have consistently identified Mesoamerica as one of the oldest and most dynamic areas for plant management and domestication, as well as for the diversification of agricultural systems in America (Harlan, 1975; Smith, 2006; Vavilov, 1926).

Supporting this, data indicate that Mesoamerica, which occupies more than 50% of Mexican territory, is one of the eight or nine regions where agriculture is believed to have originated approximately 10,000 years ago (Harlan, 1975; Vavilov, 1926). According to Casas et al. (2017), Mexico is estimated to have at least 500 species of cultivated and domesticated plants, of which 200 are native species. Overall, more than 200 domesticated and cultivated species have been documented in Mesoamerica, alongside managing between 600 and 700 wild species within Mexican territory (CONABIO et al., 2019).

Given the aforementioned, the relevance of home gardens in Mexico has been emphasized due to their complexity, biological diversity, and socio-environmental services they provide. This paper analyzes the floristic richness of home gardens in south-southeast Mexico by compiling results from 136 studies that provide information on plant species found in these home gardens. For the purposes of this study, the south-southeast region includes the following states: Guerrero, Oaxaca, and Chiapas along the Pacific coast; Veracruz, Tabasco, Campeche, and Yucatan on the Gulf of Mexico coast; and Quintana Roo along the Caribbean Sea coast. This territory covers 474,526 km$^2$ (accounting for 25.62% of Mexico's total area).

Within the south-southeast region, there are ten biocultural priority regions for conservation and development. These areas are noted for their overlapping Indigenous territories and natural and cultivated diversity. The identified regions are (a) Chontalpa in Tabasco, (b) El Triunfo-Encrucijada-Motozintla in Chiapas, (c) Altos de Chiapas-Lacandona in Chiapas, (d) Yucatan Peninsula, which includes Campeche, Quintana Roo, and Yucatan, (e) Sierra de Taxco, Lagunas Zempoala, La Malinche in Guerrero, (f) Sierra Mixteca-Triqui, Papagayo-Ometepec Basin in Guerrero, (g) Sierra Sur de Oaxaca, (h) Zongolica-Sierra Norte de Oaxaca, (i) Selva Zoque-Sepultura-Malpaso in Oaxaca and Chiapas, and (j) Los Tuxtlas-Sierra Santa

Marta in Veracruz (Boege, 2008). These factors highlight the importance of achieving a more detailed approach to home garden diversity in south-southeast Mexico.

## 6.2 Material and Methods

### *6.2.1 Study Area*

The study area is located in the south-southeast region of Mexico, which includes the states of Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatan.

This territory is divided into six biogeographic provinces: (a) Chiapas Highlands province, located in the central part of the state and dominated by temperate forest; (b) Veracruzan province, which includes a portion of the Gulf of Mexico and the states of Veracruz, Tabasco, and Campeche; it is characterized by the existence of tropical rainforest and, to a lesser extent, cloud forest, tropical deciduous forest, xerophytic scrub, and coastal lagoons with mangroves; (c) Pacific Lowlands province, which includes the coast of Guerrero, Oaxaca, and Chiapas; it is dominated by humid and tropical dry forests, savannas, palm crops, and mangroves with coastal lagoons; (d) Sierra Madre del Sur province, which comprises the mountainous area that extends from Guerrero to the Isthmus of Tehuantepec in Oaxaca, characterized by the presence of temperate forests and tropical deciduous forests; (e) Balsas Basin province, which comprises the northern portion of Guerrero and Oaxaca, dominated by temperate forests and tropical deciduous forests; and (f) Yucatan Peninsula province, located in Campeche, Quintana Roo, and Yucatan, mainly with tropical rainforest vegetation and, to a lesser extent, tropical deciduous forest (Morrone, 2005, 2019; Morrone et al., 2017).

The south-southeast region of Mexico stands out in importance, as it is inhabited by 66% of the total Indigenous peoples of the country, representing 45 different Indigenous groups (see Table 6.1). Among the states in the region, Oaxaca has the highest number of Indigenous groups, totalling 16. This is followed by Chiapas with 14, Campeche with 12, Veracruz with 11, Quintana Roo with 10, Tabasco with 6, Guerrero with 4, and Yucatan with 1 (INPI, 2020a, 2020b, 2020c, 2020d, 2020e, 2020f, 2020g, 2020h). Of these groups, 34 have inhabited their territory for hundreds and/or thousands of years (CONABIO, 2024).

## 6.3 Methodological Design and Data Collection Tools

According to the 2022 Mexican Agricultural Census, which provides information on agricultural and forestry production units by state, estimates were made regarding the number of home gardens and their surface area in the south-southeast region

**Table 6.1** Indigenous peoples inhabiting the south-southeast region of Mexico, by state

| Indigenous peoples | Campeche | Chiapas | Guerrero | Oaxaca | Quintana Roo | Tabasco | Veracruz | Yucatan |
|---|---|---|---|---|---|---|---|---|
| Akateko | X | X | | | X | | | |
| Amuzgo | | | X | X | | | | |
| Awakateko | X | | | | | | | |
| Ch'ol | X | X | | | | X | | |
| Chatino | | | | X | | | | |
| Chinanteco | | | | X | | | X | |
| Chocholteco | | | | X | | | | |
| Chontal de Oaxaca | | | | X | | | | |
| Chuj | X | X | | | X | | | |
| Cuicateco | | | | X | | | | |
| Huasteco | | | | | | | X | |
| Huave | | | | X | | | | |
| Ixcateco | | | | X | | | | |
| Ixil | X | | | | X | | | |
| Jakalteco | X | X | | | X | | | |
| K'iche | X | X | | | X | | | |
| Kakchiquel | X | | | | X | | | |
| Lacandón | | X | | | | | | |
| Mam | X | X | | | X | | | |
| Maya | X | | | | X | | | X |
| Mazateco | | | | X | | | X | |
| Mixe | | | | X | | | | |
| Mixteco | | | X | X | | | | |
| Mixteco (Tacuate) | | | | X | | | | |
| Mocho (qato'k) | | X | | | | | | |

(continued)

**Table 6.1** (continued)

| Indigenous peoples | Campeche | Chiapas | Guerrero | Oaxaca | Quintana Roo | Tabasco | Veracruz | Yucatan |
|---|---|---|---|---|---|---|---|---|
| Nahua | | | X | X | | X | X | |
| Oluteco | | | | | | | X | |
| Otomí | | | | | | | X | |
| Popoluca de la sierra | | | | | | | X | |
| Q'anjob'al | | X | | | X | | | |
| Q'anjob'al | X | | | | X | | | |
| Q'eqchi | X | | | | | | | |
| Sayulteco | | | | | | | X | |
| Tejo | | X | | | | | | |
| Tepehua | | | | | | | X | |
| Texistepequeño | | | | | | | X | |
| Tlapaneco | | | X | | | | | |
| Tojolabal | | X | | | | | | |
| Totonaco | | | | | | | X | |
| Triqui | | | | X | | | | |
| Tseltal | | X | | | | X | | |
| Tsotsil | | X | | | | | | |
| Zapoteco | | | | X | | | | |
| Zoque | | X | | X | | X | | |
| Ayapaneco | | | | | | X | | |
| Chontal de Tabasco | | | | | | X | | |

Source: Authors' elaboration based on the Atlas of Indigenous people of Mexico (INPI, 2020a, 2020b, 2020c, 2020d, 2020e, 2020f, 2020g, 2020h)

of Mexico. To arrive at these estimates, 10% was deducted from the total number of agricultural and forestry production units reported for each state. This deduction accounts for cattle-raising households, as families managing those units typically spend only a few months on the property. Therefore, 90% of the total number of production units was considered the total number of home gardens in each state.

As a baseline for determining the floristic richness, as well as common names and uses of plant species in these home gardens, research was conducted from 2010 to 2024. This involved tracing, compiling, and classifying specialized literature and bibliographic sources containing specific information on home gardens and related types (such as patio, solar, and backyard). The research utilized different academic research databases and sought information stored in regional (state) university libraries, focusing on locating bachelor's, master's, or doctoral theses (which often contain unpublished material). Finally, information from the National Commission for the Knowledge and Use of Biodiversity of Mexico's databases was reviewed.

A total of 136 studies provided information related to species found in home gardens, patios, and backyards in the south-southeast region of Mexico. Oaxaca had the highest number of publications, totalling 26, followed by Veracruz with 22, Yucatan with 20, Chiapas with 17, and both Campeche and Tabasco, each with 16 studies. Quintana Roo had 10 publications, while Guerrero had 9. To complement the information for each species reported (biological form, origin, extinction risk status, use, and management), additional bibliographic sources were consulted, resulting in a total of 2589 bibliographic references. Figure 6.1 shows the different types of bibliographic sources used, along with the total number recorded for each type of publication.

## 6.4 Data Processing and Analysis

To systematize, process, and analyze the information, databases were created in Microsoft Access and Microsoft Excel. These databases included data on the taxonomic classification of each species (which involved comparison of the taxonomic status of the names: accepted or synonymous, and ensuring the correct citation of each species: accepted name). Additionally, taxonomic, biogeographical, and ethnobotanical information for each species was included, such as plant form, origin, uses, and extinct risk status. Finally, information related to their distribution at the state level was also incorporated.

For the systematic organization of the information in these databases, the processing was guided by the methodology proposed by CONABIO for constructing ethnobiological information systems (Gual-Díaz, 2018).

The analysis focused on species richness, which corresponds to the total number of species present. This metric can be used to measure biodiversity and compare different sites (Magurran, 1988).

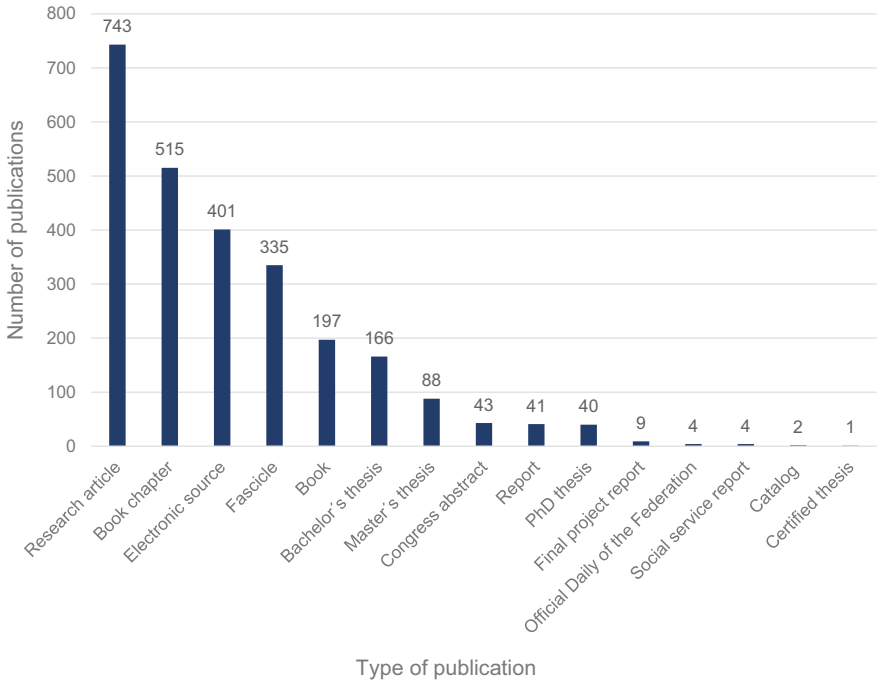



**Fig. 6.1** Number and type of publications consulted to establish the database on home gardens in south-southeast Mexico (2589 references in total)

## 6.5 Results

### *6.5.1 Number and Surface Area of Home Gardens in South-Southeast Mexico*

The estimated total number of home gardens in the south-southeast region of Mexico is 1,760,031 (see Table 6.2). With a surface calculation of 20 m × 30 m (600 $m^2$ or 0.06 ha) per home garden, this is equivalent to 105,602 ha or 105.6 $km^2$. In other words, the south-southeast region of Mexico has nearly 1.8 million areas dedicated to polyculture and animal husbandry of various species, which can support up to 8.8 million people for a significant part of the year.

These home gardens can supply local markets year-round with a wide variety of fruits, vegetables, legumes, seeds, roots, tubers, medicinal plants, and different kinds of meat, as well as animals and their by-products. However, the volumes mentioned above have not yet been quantified in Mexico. Therefore, it is considered appropriate to conduct further studies on this topic to achieve a more accurate approximation.

**Table 6.2** Production units, estimated number, and estimated surface area (ha) of home gardens in south-southeast Mexico, by state

| State | Number of production units | Estimated number of home gardens | Estimated area of home gardens in hectares (600 $m^2$/home garden) |
|---|---|---|---|
| Guerrero | 218,795 | 196,916 | 11,815 |
| Oaxaca | 409,554 | 368,599 | 22,116 |
| Chiapas | 507,377 | 456,639 | 27,398 |
| Veracruz | 551,221 | 496,099 | 29,765 |
| Tabasco | 125,011 | 112,510 | 6751 |
| Campeche | 55,120 | 49,608 | 2976 |
| Quintana Roo | 28,197 | 25,377 | 1523 |
| Yucatan | 60,315 | 54,283 | 3257 |
| Total | 1,955,590 | 1,760,031 | 105,601 |

Source: Authors' elaboration (2024) based on information published in the Agricultural Census (INEGI, 2023a, 2023b, 2023c, 2023d, 2023e, 2023f, 2023g, 2023h, 2023i)

An example will be given for comparison purposes. Mexico is the world's leading producer of avocado (*Persea americana*). By 2022, the country produced 2.5 million metric tonnes of avocados, cultivated on just over 250,000 ha (SIAP, 2024). In this context, the surface area of home gardens in the south-southeast region of Mexico accounts for 42% of the total area cultivated with avocados. If food production in these home gardens were similar to that of avocados, we would see over 1 million tonnes of food produced in home gardens. This highlights the important role of these agroecosystems, which are widely distributed in tropical and intertropical regions worldwide (Cano-Contreras, 2015).

## 6.6 Floristic Richness of Home Gardens

In the home gardens of the south-southeast region of Mexico, a total of 1452 plant species were registered. There was significant variation in species richness by state. Tabasco had the highest diversity, with 642 species, while Guerrero had the lowest, with only 174 species (refer to Table 6.3).

This difference may seem logical, as Tabasco is characterized by a warm and humid climate with humid tropical forests (both evergreen and sub-evergreen). In contrast, Guerrero has a hot and dry climate, where tropical deciduous and sub-deciduous forests are predominant. However, it is important to highlight that these findings may vary over the years as more studies are conducted in Guerrero. It is recognized that larger states with more complex orography, such as Chiapas, Oaxaca, Guerrero, and Veracruz, are under sampled.

In this regard, there is a need for studies on plant species of home gardens located in areas dominated by tropical deciduous and sub-deciduous forests. According to Lott and Atkinson (2010) and Trejo (2010), these forests, found in the Mexican

**Table 6.3** Floristic richness of home gardens in the south-southeast region of Mexico, by state

| State | Floristic richness (number of species) | % with respect to the total floristic richness of south-southeast Mexico |
|---|---|---|
| Guerrero | 174 | 12.0% |
| Oaxaca | 406 | 28.0% |
| Chiapas | 438 | 30.2% |
| Veracruz | 245 | 16.9% |
| Tabasco | 642 | 44.2% |
| Campeche | 571 | 39.3% |
| Quintana Roo | 292 | 20.1% |
| Yucatán | 453 | 31.2% |
| Total | 1452 | 100% |

Source: Authors' elaboration based on the systematization and analysis of information (2010–2024)

Southern Pacific (Michoacan, Guerrero, and Oaxaca), play a fundamental role in conserving floristic diversity due to their high level of plant endemism at the species level.

No proportional relationship was found when simultaneously analyzing the floristic richness of home gardens across different states. This analysis considered the overall number of plant species present in each state's territory and the number of Indigenous peoples within those states, which was not in line with expectations (see Table 6.4 and Fig. 6.2). This discrepancy can be attributed to the lack of studies that provide detailed information about the plant species found in home gardens of all Indigenous peoples inhabiting each state, as well as a lack of data regarding altitudinal distribution.

The data on food species reported in home gardens was compared with the information on cultivated plants of economic importance registered in the Agricultural and Fishing National Information System (DGSIAP, 2024). Considerable biases were found, since the total number of food species of home gardens in the south-southeast region, which amounted to 746 species (51.4%), is much higher than the 143 species reported in the national statistics of cultivated plants of economic importance. This indicates an underestimation of at least 80.8%. This figure is particularly important because food species from other agricultural systems, such as milpa—distributed across the territory and where more than 100 cultivated species associated with maize are grown (according to our field work observations)—were not included.

Regarding the number of food species per state, differences ranged from 9.1% and 12.62% in Guerrero and Tabasco, respectively, to 83.3% and 87.4% in Quintana Roo and Campeche (Table 6.5).

Regarding the plant taxonomy of the total number of species found in the home gardens of south-southeast Mexico, they were classified into three taxonomic divisions; Class Magnoliopsida (Magnoliophyta Division) had the highest number of species, with 1422 (refer to Table 6.6).

**Table 6.4** States, state surface area (km$^2$), number of Indigenous peoples, number of plant species, position in plant diversity in south-southeast Mexico, number of plant species in home gardens, position in plant diversity in home gardens in south-southeast Mexico, and number of studies on home gardens

| State | State surface area (km$^2$) | Number of Indigenous peoples | Number of plant species | Position in plant diversity in south-southeast Mexico | Number of plant species in home gardens | Position in plant diversity in home gardens in south-southeast Mexico | Number of studies on home gardens |
|---|---|---|---|---|---|---|---|
| Guerrero | 65,596 | 4 | 2463 | 4th (5th national) | 174 | 8° | 9 |
| Oaxaca | 93,343 | 14 | 4085 | 3rd (3rd national) | 406 | 5° | 26 |
| Chiapas | 73,311 | 13 | 4548 | 2nd (2nd national) | 438 | 4° | 17 |
| Veracruz | 71,824 | 10 | 5472 | 1st (1st national) | 245 | 7° | 22 |
| Tabasco | 24,131 | 7 | 1282 | 5th (18th national) | 642 | 1° | 16 |
| Campeche | 57,507 | 2 | 839 | 7th (26th national) | 571 | 2° | 16 |
| Quintana Roo | 50,212 | 1 | 790 | 8th (28th national) | 292 | 6° | 10 |
| Yucatán | 38,402 | 1 | 842 | 6th (25th national) | 453 | 3° | 20 |
| Total | 474,526 | 34 | N.C. | – | 1452 | | 136 |

Source: Authors' elaboration based on the systematization of information (2024); with data from Llorente-Bousquets and Ocegueda (2008) cited in CONABIO (2024).
*N.C.* Not calculated

Vascular plants (Magnoliophyta) are highly significant in terms of their species representativeness, both nationally and in home gardens. Overall, Mexico ranks among the top countries in Magnoliophyta biodiversity, following Colombia and Brazil, with a total of 22,411 species for Mexico (Magaña & Villaseñor, 2022). Therefore, based on the results obtained in this work, it can be confirmed that the home gardens of the south-southeast region serve as a reservoir for 6.5% Mexico's total Magnoliophyta biodiversity.

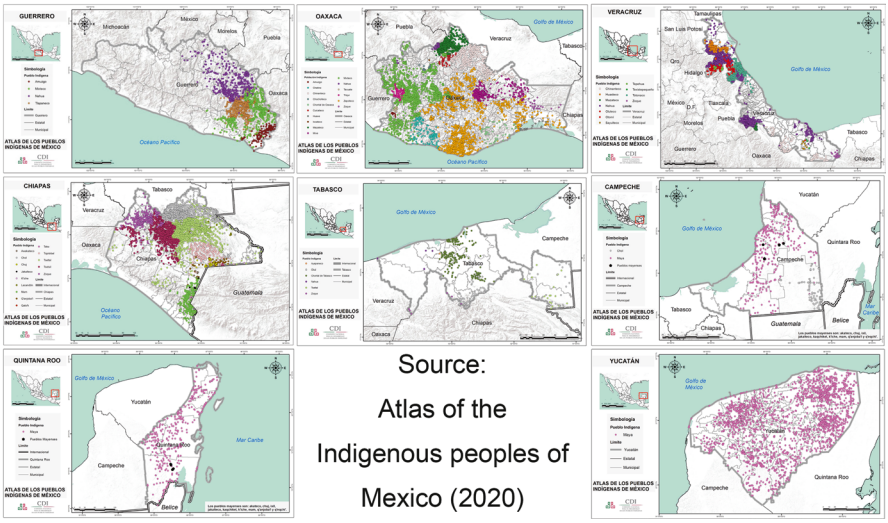



**Fig. 6.2** Indigenous peoples in the south-southeast region of Mexico, by state (INPI, 2020a, 2020b, 2020c, 2020d, 2020e, 2020f, 2020g)

**Table 6.5** State, number of plants in home gardens, estimated number of food plants, number of plants of economic importance reported in the Agricultural and Fishing National Information System (SIAP), number and percentage of species not considered in SIAP

| State | Number of plants in home gardens | Estimated number of food plants | Number of plants of economic importance[a] | Number of species not considered in DGSIAP[b] | Percentage of species not considered in DGSIAP |
|---|---|---|---|---|---|
| Guerrero | 174 | 89 | 82 | 7 | 9.1% |
| Oaxaca | 406 | 209 | 69 | 140 | 66.0% |
| Chiapas | 438 | 225 | 57 | 168 | 74.7% |
| Veracruz | 245 | 126 | 96 | 30 | 66.2% |
| Tabasco | 642 | 330 | 42 | 288 | 12.62% |
| Campeche | 571 | 293 | 37 | 244 | 87.4% |
| Quintana Roo | 292 | 150 | 25 | 125 | 83.3% |
| Yucatán | 453 | 233 | 49 | 184 | 79.0% |
| Total[c] | 1452 | 746 | 143 | 603 | 80.8% |

[a]According to information published by DGSIAP (2024). The data was reduced by the number of replicates of a single species, e.g., grain maize, fodder maize, corn, among others

[b]Since DGSIAP (2024) species approach only considers species of economic importance, this is the number of species left out of the statistics, when compared with the number of food species from the home gardens

[c]These totals are not sums, as there are many shared species among states

**Table 6.6** Division, class, family, genus, and species of plants from the home gardens of south-southeast Mexico

| Division | Class | Number of families | Number of genera | Number of species |
|---|---|---|---|---|
| Polypodiophyta (ferns) | Equisetopsida | 1 | 1 | 3 |
| | Polypodiopsida | 7 | 9 | 9 |
| Pinophyta (gymnosperms) | Cycadatae | 2 | 3 | 4 |
| | Pinatae | 4 | 7 | 14 |
| Magnoliophyta (flowering plants) | Liliopsida | 24 | 136 | 246 |
| | Magnoliopsida | 125 | 671 | 1176 |
| Total | | 164 | 828 | 1452 |

Source: Authors' elaboration based on the systematization of information (2010–2024)

Pinophyta is also important; a total of 94 species have been documented for Mexico, where 49% of which are endemic to the country (Gernandt & Pérez-de la Rosa, 2014). Notably, this study registered 19% of the total Pinophyta species reported in Mexico, indicating that home gardens play a crucial role in conserving the country's Pinophyta germplasm.

The total number of species reported in the home gardens was categorized into 164 botanical families, 801 genera, and 1452 species. Of this total, 75.4% (1095 species) belong to 38 plant families that are considered megadiverse, both globally and in Mexico. These families are notable for their extensive management and use by rural and semi-rural communities. The five botanical families with the highest species diversity are Fabaceae with 149 species, Asteraceae with 97 species, Malvaceae with 67 species, Euphorbiaceae with 57 species, Solanaceae with 51 species, and Lamiaceae with 49 species (refer to Fig. 6.3).

## 6.7 Dominant Plant Forms in the Home Gardens

Based on their plant form (herbs, shrubs, or trees), it was found that 51.8% of the plant species were trees (800 species), while 48.2% (743 species) were a combination of shrubs and herbs. This finding is particularly significant, as our field observations over the years indicate that the home gardens are primarily managed by farmers' wives. These women tend to imitate the surrounding vegetation, cultivating plants in at least three vegetation strata: herbs, shrubs, and trees. In older home gardens, the strata can sometimes reach up to five or six.

The dominance of tree species in the home gardens of south-southeast Mexico, which comprises 51.8% of the total number of species, contrasts sharply with findings reported by Caballero et al. (2010). In their study of biodiversity management in Mexican home gardens, they found that the highest percentage of useful species consisted of herbaceous plants (51%), followed by trees (27%) and shrubs (21%).

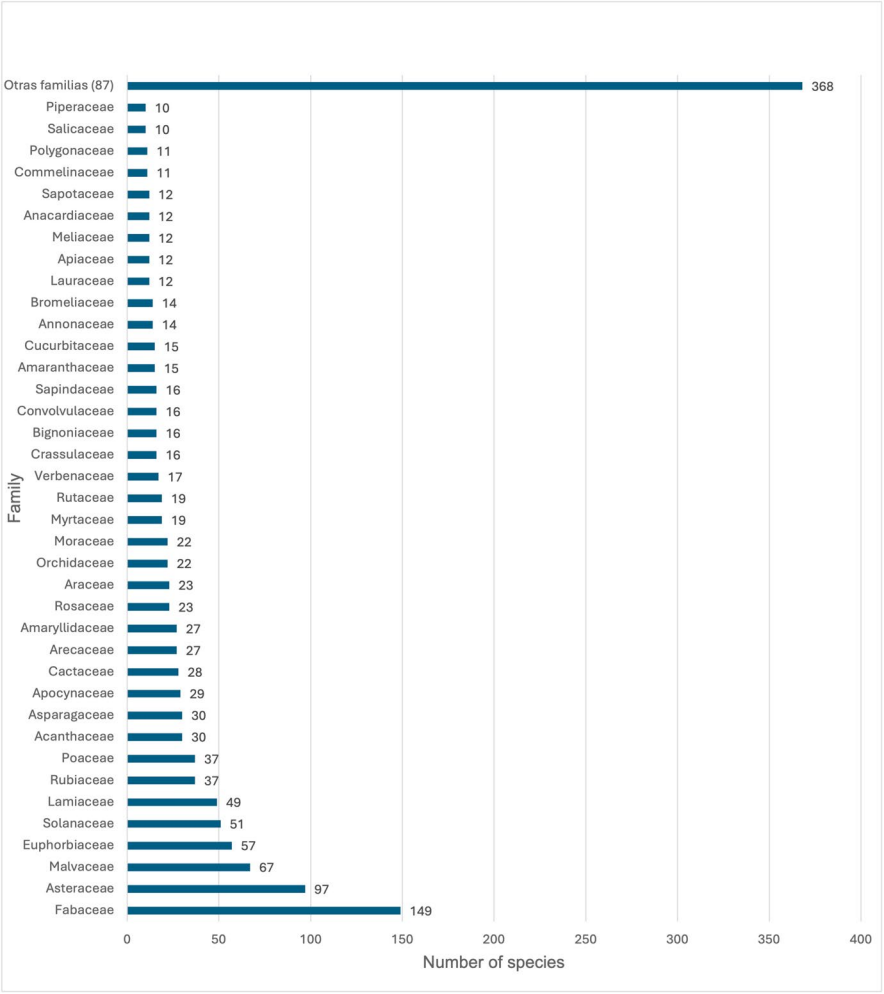



**Fig. 6.3** Most representative botanical families of home gardens in south-southeast Mexico. Source: Authors' elaboration based on the systematization of information (2010–2024)

## 6.8 Origin of the Floristic Elements of Home Gardens

An important aspect of the present study is that the origin of plant species was analyzed; this is highlighted because most studies on home gardens in Mexico did not include this information. It was found that 10% (155 species) are endemic to Mexico, 34% (529 species) are introduced to the country, and 56% (859 species) are native to Mexico, with a regional distribution in North, Central, and South America. This clearly highlights the significance of home gardens for the conservation of

native and endemic plants in Mexico, since the highest percentage of species inhabiting this agroecosystem are native, with a smaller proportion being endemic.

As previously mentioned, the region studied is one of the original centres for crops, such as Mesoamerica, which experienced important exchange of species with Central America and South America before and after the sixteenth century. To corroborate this, it has been estimated that, by the time Europeans arrived, the agroecosystems in Mesoamerica already contained between 110 and 130 domesticated species (Boege, 2008; Caballero et al. 2010; Hernández, 1985).

## 6.9 Types of Uses of the Floristic Elements of Home Gardens

Regarding the types of uses and environmental services reported for species in home gardens, 77 botanical families with multipurpose species stood out, totalling 374 species. In total, 24 families had between 5 and 83 species classified as multipurpose. It is important to note that uses vary among states, cultures, and Indigenous peoples (see Table 6.7), which shows that each culture develops its knowledge system about plant use.

The botanical families with the highest number of multipurpose species were Fabaceae with 56 species, Malvaceae with 19, and Rutaceae with 10. This suggests that leguminous plants are an essential part of the diet of various social groups, serve as key ornamental plants, and are an important source for ceremonial or religious uses. The Rutaceae family, which includes citrus fruits, is mainly used as a source of food and medicine.

In addition to the above-mentioned, it was found that for some of the 38 botanical families with the highest number of species (which account for 75.4% of the recorded species, totalling 1095 species), a high number of uses were registered. Examples include Fabaceae (mentioned earlier), where its species are mainly used

**Table 6.7** Botanical families (24) of home gardens in south-southeast Mexico with multipurpose species (five or more species)

| Botanical family | Number of species |
|---|---|
| Fabaceae | 83 |
| Malvaceae | 21 |
| Euphorbiaceae | 13 |
| Asteraceae | 12 |
| Apocynaceae, Arecaceae, Moraceae, Rutaceae | 11 |
| Anacardiaceae, Bignoniaceae, Rosaceae, Sapotaceae | 9 |
| Myrtaceae, Lamiaceae | 8 |
| Annonaceae, Asparagaceae, Polygonaceae, Rubiaceae | 7 |
| Cactaceae, Cucurbitaceae | 6 |
| Cordiaceae, Malpighiaceae, Meliaceae, Salicaceae | 5 |

Source: Authors' elaboration based on the systematization of information (2010–2024)

for food and construction materials; Asteraceae, primarily used for food and medicinal purposes; Malvaceae, used for food, firewood, construction materials, and medicinal purposes; Euphorbiaceae, used for food, fuel, and medicinal purposes; and finally, Solanaceae, used for food and medicine (refer to Table 6.8).

It is noteworthy that the families previously mentioned also held important positions when analyzing information by state. For example, Fabaceae ranked first in species diversity in Chiapas (46 species), Guerrero (28), Tabasco (96), Quintana Roo (42), and Yucatan (55). Asteraceae ranked first in species diversity in Oaxaca (49 species), second in Tabasco (71), and third in Campeche (23), Guerrero (13), and Yucatan (22), respectively. Malvaceae was second in species diversity in Chiapas (23 species) and third in both Tabasco (64) and Quintana Roo. Finally, Euphorbiaceae ranked second in Campeche (32 species), Quintana Roo (16), and Yucatan (23) (refer to Table 6.8).

The information shown in Table 6.8 highlights the significance of these botanical families as a source of food, medicines for health care (mainly used for self-care), and raw construction materials. In addition, they offer various environmental services, such as providing food and shelter for wildlife, offering shade, serving as windbreaks, supplying as raw material for fences and live posts, aiding in soil formation and nitrogen fixation, acting as melliferous plants, and including ornamental plants that enhance beauty, among others (refer to Fig. 6.4). All of these points clearly emphasize the notable features of this agroecosystem, inhabited by rural and semi-rural communities in south-southeast Mexico.

When analyzing the reported uses for each species (refer to Fig. 6.5), it was found that the highest percentage, 54.7% (794 species), is used for medicinal purposes, mainly in domestic self-care. Next, 51.4% (746 species) serve as food sources for wildlife; third, 35.6% (517 species) are used in the construction of both minor and major infrastructure; then, 33.4% (485 species) are sources of fuel, mainly firewood or charcoal, which are essential for daily food preparation and other needs in many rural communities in south-southeast Mexico. These are followed by 31.2% (453 species) used for timber; 28.4% (413 species) have ceremonial or ritual uses; and 9.4% (136 species) are utilized for handicrafts.

The above reflects the primary uses of flora by rural populations in the south-southeast region of Mexico. It is important to note that this data does not match the total number of species found, because, as mentioned earlier in the text, many species have multiple uses.

A detailed analysis of medicinal species was conducted. First, it is important to highlight that Mexico ranks among the top countries globally in medicinal plant diversity, with an estimated 5000 species (Torres-Avilez et al., 2015). In addition, it should be noted that natural resources, mainly plants, have played a crucial role in the healthcare practices of various social groups in Mexico.

Overall, the results regarding the number of plant species found in home gardens clearly show high diversity and highlight the importance of natural resources for healthcare in south-southeast Mexico. First, it should be noted that home gardens contain 16% of Mexico's estimated medicinal plant diversity, including endemic, native, and introduced species. Second, the significance of plants as healthcare

**Table 6.8** Botanical families with the highest number of species (ten or more species) and its main uses, total number of species in the home gardens, and position by number of species in each state

| APG botanical families (2016) and main uses | Total number of species in the home gardens | Position by number of species in each state (number of species is shown in parentheses) |
|---|---|---|
| **Fabaceae**<br>Food, fuel, construction, manufacturing, and medicinal | 149 | 1st position: Campeche (71), Chiapas (46), Guerrero (28), Tabasco (96), Quintana Roo (42) and Yucatan (55). Also, Yucatan Peninsula as a region (85)<br>2nd position: Oaxaca (22) |
| **Asteraceae**<br>Food and medicinal | 97 | 1st position: Oaxaca (49)<br>2nd position: Tabasco (71)<br>3rd position: Campeche (23), Guerrero (13), and Yucatan (22). Also, Yucatan Peninsula as a region (31)<br>4th position: Chiapas (22)<br>6th position: Quintana Roo (11) |
| **Malvaceae**<br>Food, fuel, construction, manufacturing, and medicinal | 67 | 2nd position: Chiapas (23)<br>3rd position: Tabasco (64), Quintana Roo (12)<br>4th position: Campeche (22) and Yucatan Peninsula as a region (28)<br>5th position: Yucatan (17)<br>8th position: Oaxaca (14) |
| **Euphorbiaceae**<br>Food, fuel, construction, manufacturing, and medicinal | 57 | 2nd position: Campeche (32), Quintana Roo (16), Yucatan (23), and Yucatan Peninsula as a region (38)<br>6th position: Tabasco (38)<br>8th position: Chiapas (12) |
| **Solanaceae**<br>Food and medicinal | 51 | 3rd position: Chiapas (23)<br>5th position: Campeche (22)<br>6th position: Oaxaca (15)<br>7th position: Tabasco (34), Quintana Roo (11), and Yucatan Peninsula as a region (24)<br>9th position: Yucatan (11) |
| **Lamiaceae**<br>Food and medicinal | 49 | 3rd position: Oaxaca (20)<br>4th position: Tabasco (62) and Quintana Roo (12)<br>5th position: Chiapas (14)<br>6th position: Campeche (18), Yucatán (15) and Yucatan Peninsula as a region (24) |
| **Rubiaceae**<br>Fuel, construction, manufacturing, and medicinal | 37 | 4th position: Yucatan (18)<br>7th position: Chiapas (12)<br>8th position: Yucatan Peninsula as a region (22)<br>10th position: Yucatan Peninsula as a region (44)<br>11th position: Campeche (13) and Tabasco (26) |
| **Poaceae**<br>Food, handicraft, construction, elaboration, and medicinal | 37 | 8th position: Tabasco (32)<br>14th position: Yucatan Peninsula as a region (15) |
| **Acanthaceae**<br>Medicinal | 30 | 9th position: Yucatan Peninsula as a region (20) |

(continued)

**Table 6.8** (continued)

| APG botanical families (2016) and main uses | Total number of species in the home gardens | Position by number of species in each state (number of species is shown in parentheses) |
|---|---|---|
| **Asparagaceae**<br>Food, construction, elaboration, and medicinal | 30 | 5th position: Oaxaca (16)<br>11th position: Yucatan (11)<br>12th position: Campeche (12)<br>15th position: Yucatan Peninsula as a region (15) |
| **Apocynaceae**<br>Fuel, construction, elaboration, and medicinal | 29 | 5th position: Yucatan Peninsula as a region (24)<br>8th position: Campeche (18)<br>10th position: Chiapas (11)<br>13th position: Yucatan (11)<br>29th position: Tabasco (14) |
| **Cactaceae**<br>Food and medicinal | 28 | 9th position: Oaxaca (13)<br>13th position: Campeche (11) and Yucatan Peninsula as a region (15)<br>33th position: Tabasco (11) |
| **Amaryllidaceae**<br>Food, ceremonial or ritual, and medicinal | 27 | 17th position: Tabasco (21)<br>18th position: Campeche (10) and Yucatan Peninsula as a region (12) |
| **Arecaceae**<br>Food, fuel, construction, elaboration, and medicinal | 27 | 5th position: Quintana Roo (12)<br>7th position: Campeche (18)<br>10th position: Yucatan (11)<br>11th position: Yucatan Peninsula as a region (18)<br>13th position: Tabasco (24) |
| **Araceae**<br>Food, ceremonial or ritual, construction, and elaboration | 23 | 16th position: Campeche (11)<br>17th position: Yucatan Peninsula (13)<br>26th position: Tabasco (15) |
| **Rosaceae**<br>Food, fuel, and medicinal | 23 | 4th position: Oaxaca (16)<br>9th position: Chiapas (11)<br>23th position: Tabasco(16) |
| **Moraceae**<br>Food, fuel, construction, elaboration, and medicinal | 22 | 10th position: Campeche (14)<br>12th position: Yucatan (11) and Yucatan Peninsula as a region (16)<br>16th position: Tabasco (22) |
| **Orchidacea**<br>Food, ceremonial or ritual, and medicinal | 22 | 14th position: Campeche (11)<br>19th position: Yucatan Peninsula as a region (11) |

Source: Authors' elaboration based on the systematization of information (2010–2024)

resources is evident, given that half of the total species reported in the home gardens are recognized as medicinal.

The number of medicinal species reported for home gardens in south-southeast Mexico (794 species) exceeds the total number of medicinal species reported for home gardens in Mexico by Caballero et al. (2010), which was 572 species. Therefore, it is important to continue conducting studies that improve the

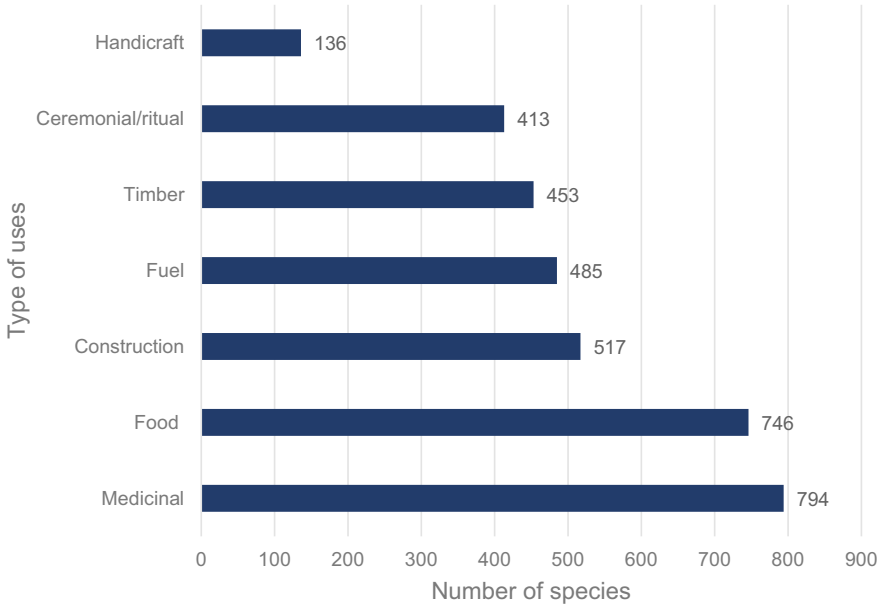



**Fig. 6.4** Main types of uses of the flora of home gardens in south-southeast Mexico. Source: Authors' elaboration based on the systematization of information (2010–2024)

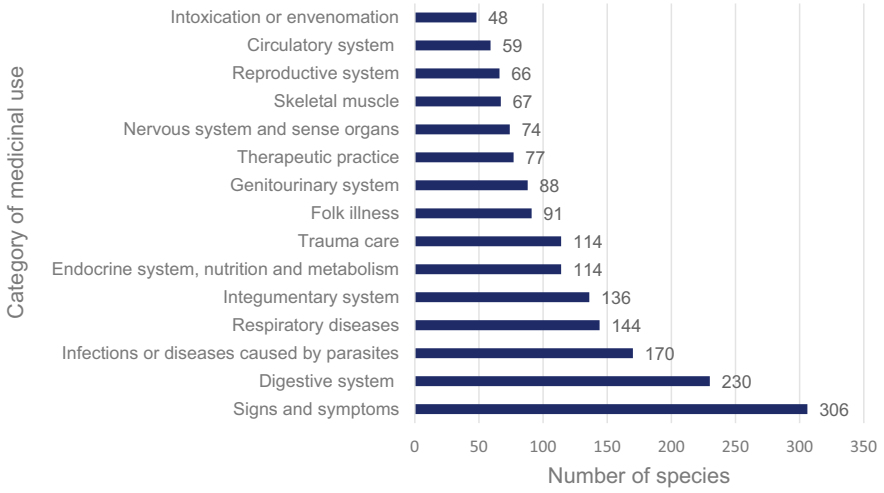



**Fig. 6.5** Main medicinal uses of plants from the home gardens of south-southeast Mexico. Source: Authors' elaboration based on the systematization of information (2010–2024)

knowledge of medicinal species in home gardens from central and northern Mexico. This will provide a more accurate, precise, and up-to-date estimate of the number of medicinal species present in home gardens throughout Mexico.

The following are some native species considered among the most representative of home gardens in south-southeast Mexico, based on information from our database and reviewed literature.

The "palo de temazate" or "*tsajal ch'it*" (Tsotsil language) [*Eugenia capuli* (Schltdl. & Cham.) Hook. & Arn.] is a tree or shrub found in various types of forests: gallery, *Pinus*, *Pinus-Quercus*, *Quercus* cloud forest, as well as tropical deciduous, sub-deciduous, evergreen, and sub-evergreen (Campeche, Chiapas, Guerrero, Quintana Roo, Tabasco, Veracruz, and Yucatan). Its most common uses include treating respiratory diseases like whooping cough, skin pimples, stomach infections such as diarrhea and dysentery, and energy cleansings as a therapeutic practice.

Another representative species is "*yoloxóchitl*" (which means "flower of the heart" in Nahuatl) or "*guia lachi*" (in Zapotec) (*Magnolia mexicana* DC.). This exceptional tree can be found in *Pinus-Quercus*, cloud, and evergreen forests of Guerrero, Oaxaca, and Veracruz. It plays a significant role as a medicinal plant in the home gardens of the states previously mentioned. The main uses of yoloxóchitl include treating heart diseases, diarrhea, a tilted uterus, and sterility. It is also used to relieve symptoms such as heartburn, tiredness, fever, and inflammation. Additionally, it helps address folk ailments like fright and sadness, as well as disorders of the nervous system, acting as an anticonvulsant and aiding in treating paralysis.

An endemic species that needs highlighting is the "*cuachalalate*" (in Nahuatl) or "*ya'a cuachalala*" (in Zapotec) [*Amphipterygium adstringens* (Schltdl.) Standl.], a tree or shrub endemic to the tropical deciduous and sub-deciduous forests of Guerrero and Oaxaca. The most common uses of this species include treating hemorrhoids, stomach and colon cancer, mouth ulcers, respiratory diseases such as whooping cough, malaria, reducing fever and inflammation of the lips, urinary tract infections, high cholesterol, diabetes, kidney stones, and injuries like wounds and internal injuries.

In the home gardens of the Yucatan Peninsula, the "chactsan" (in Mayan) or "*maguey morado*" (in Spanish), also known as oyster plant or boatlilly (*Tradescantia spathacea* Sw.), is one of the most representative plants found in the region. According to Carnevali et al. (2010), this species is distributed only in the biogeographic province of the Yucatan Peninsula and surrounding areas in Central America. "*Chactsan*" holds significant value for healthcare among the Mayans, thanks to its numerous medicinal properties. It is used to treat dental caries and conditions such as blemishes, wounds, sores, and burns. Additionally, it helps with hair loss, colic or stomach cramps, and kidney stones. Moreover, it is used against tetanus, relieve headache and stomach ache, combat inflammation and vaginal infections, and address respiratory issues such as asthma, bronchitis, and cough.

An analysis was conducted on the diseases and illnesses treated with medicinal plants, with the main results presented in Fig. 6.5. The diseases and conditions that

had the highest number of medicinal species (more than 100) for treatment are as follows:

1. Attention to signs and symptoms with 306 species (38.5% of the total number of medicinal species)
2. Digestive system diseases and illnesses with 230 species (30% of the total)
3. Infections and/or diseases caused by parasites, with 170 species (21.4% of the total)
4. Respiratory diseases with 144 species (18% of the total)
5. Integumentary system (skin, hair, nerves, and glands on the skin) with 136 species (17% of the total)
6. Endocrine system and trauma care, with 114 species (14.3% of the total) for each category

A brief analysis of the top 20 leading causes of disease in Mexico, as reported by Mexico Ministry of Health for the period between 2021 and 2024 (SSA, 2020, 2021, 2022, 2023, 2024), indicated that the primary health diseases affecting the Mexican population include acute respiratory infections, urinary tract infections, intestinal infections caused by other organisms, type II diabetes, hypertension, and obesity. Notably, some health issues with the highest incidence of medicinal species overlapped with the leading cause of disease reported by the Mexican Ministry of Health. These include digestive system disorders, respiratory tract and endocrine system disorders, specifically type II diabetes.

Of particular importance is the case of folk illnesses, as highlighted by Hersch and González (2011), who refer to them as "popular nosological entities." These entities encompass different indigenous or non-indigenous understandings of health, illness/disease, and its care. A key characteristic of these folk illnesses is that they are often not acknowledged by the biomedical model of medical care. Nevertheless, they play a significant role in the health and illness care process experienced by different social groups throughout Mexico. Some of the most popular nosological entities in south-southeast Mexico include "aire" or air (various modalities), "cirro" or "tipte" (which refers to a pulsation in the navel accompanied by symptoms such as diarrhea, headache, stomach ache, loss of appetite, and weakness), "empacho," envy, the evil eye, "hipil" child, among others (BDMTM, 2009).

This information is not consistent with Mexico's Ministry of Health records dating back to 2004 (as more recent data was unavailable). This discrepancy likely arises because the rural population tends to rely on traditional doctors as well as biomedical health centres. In this regard, the health disorders that are typically addressed in biomedical health centres include ischemic heart disease, cirrhosis and other chronic liver diseases, cerebrovascular disease, chronic obstructive pulmonary disease, acute lower respiratory infections, protein-calorie malnutrition, asphyxia, and birth trauma.

Figure 6.6 presents detailed information on the environmental services provided by the plants in home gardens. The environmental service with the highest number of species registered was ornamental (747 species), followed by melliferous species (439), source of food for wildlife (436), fence or live post (298), biodiversity refuge

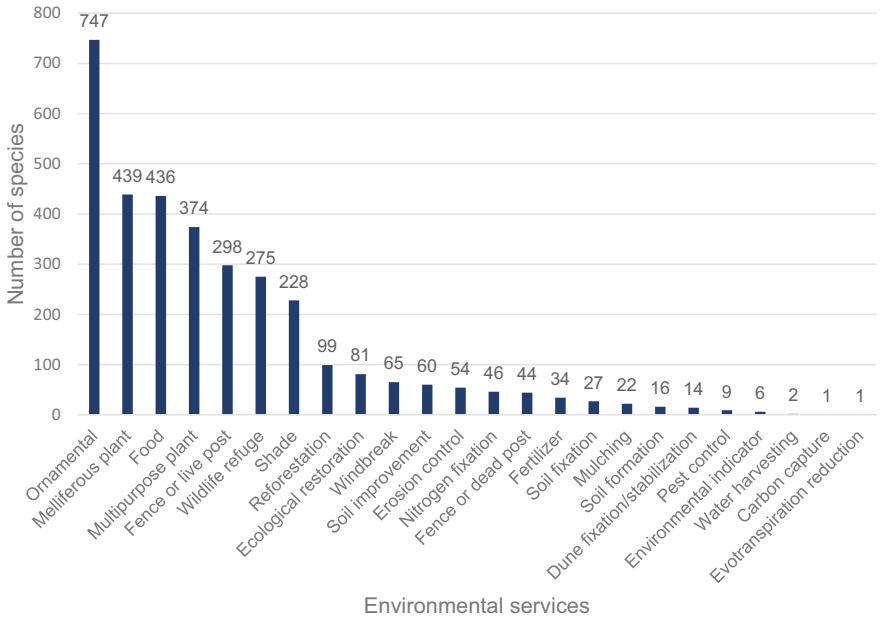



**Fig. 6.6** Environmental services provided by plant species of the home gardens in south-southeast Mexico. Source: Authors' elaboration based on the systematization of information (2010–2024)

(275), and shade (228). For the remaining environmental services, the number of reported species ranges between 1 and 99 species.

In conclusion, our study revealed that the families with the most diversity in terms of the number of species and types of uses also offered a wider range of environmental services. Specifically, we found that the primary ecological services provided by Asteraceae, Euphorbiaceae, and Fabaceae families include food and refuge for wildlife, cultivation of melliferous plants, provision of live fences and posts, ornamental uses, and nitrogen fixation (refer to Table 6.9).

## 6.10 Common Names of the Floristic Elements of the Home Gardens

Considering the biocultural mosaic of the Mexican territory and the popularity of certain plants overall in the south-southeast region of Mexico, researchers traced the species with the highest number of common names. For 26 species, more than 100 local names were reported (see Table 6.10) and were native, with the exception of "tabachín" (most popular name) or peacock flower (*Caesalpinia pulcherrima* (L.) Sw.), which, according to Villaseñor and Espinosa-García (2004), is a species introduced from the Caribbean region. However, Rzedowski and Calderón de Rzedowski (1997) note that its origin remains unknown. This indicates that these species have

**Table 6.9** Botanical families (with 20 or more species registered), environmental services, and the number of species recorded for each ecological service

| Botanical family | Environmental service | Number of species |
|---|---|---|
| Fabaceae | Honey plant | 86 |
| | Food | 81 |
| | Live fence or post | 75 |
| | Ornamental | 63 |
| | Biodiversity refuge | 55 |
| | Shade | 46 |
| | Nitrogen fixation | 38 |
| | Reforestation | 24 |
| Asteraceae | Ornamental | 40 |
| | Honey plant | 38 |
| | Food | 38 |
| Malvaceae | Ornamental | 30 |
| Euphorbiaceae | Honey plant | 28 |
| | Food | 27 |
| | Ornamental | 22 |
| Apocynaceae | Ornamental | 25 |
| Solanaceae | Ornamental | 23 |
| Arecaceae | Ornamental | 23 |
| Asparagaceae | Ornamental | 21 |
| Amaryllidaceae | Ornamental | 20 |
| Acanthaceae | Ornamental | 20 |
| Araceae | Ornamental | 20 |
| Orchidaceae | Ornamental | 20 |

Source: Authors' elaboration based on the systematization of information (2010–2024)

been utilized for many decades, or even hundreds of years, highlighting that their distribution and popular use is a process that takes significant time, not just a few years.

Finally, this lexical richness is particularly important from both linguistic and anthropological perspectives. It reflects how the natural world has been incorporated into the culture of social groups or Indigenous peoples (Aguilar, 2018).

## 6.11 Extinction Risk Status of the Floristic Elements of the Home Gardens

For each species reported, an evaluation of their conservation status was made, based on information published by national and international sources: Appendix II of the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora); the Red List of Tree Species of the Cloud Forest in Mexico

**Table 6.10** Botanical family, species, and number of common names recorded for species with more than 100 common names

| Botanical family | Species | Number of common names | Botanical family | Species | Number of common names |
|---|---|---|---|---|---|
| Malvaceae | *Guazuma ulmifolia* Lam. | 211 | Burseraceae | *Bursera simaruba* (L.) Sarg. | 122 |
| Bignoniaceae | *Tecoma stans* (L.) Juss. ex Kunth | 197 | Sapindaceae | *Sapindus saponaria* L. | 120 |
| Myrtaceae | *Psidium guajava* L. | 167 | Verbenaceae | *Lantana camara* L. | 119 |
| Anacardiaceae | *Spondias purpurea* L. | 162 | Altingiaceae | *Liquidambar styraciflua* L. | 119 |
| Bixaceae | *Cochlospermum vitifolium* (Willd.) Spreng. | 146 | Lauraceae | *Persea americana* Mill. | 118 |
| Fabaceae | *Pithecellobium dulce* (Roxb.) Benth. | 139 | Moraceae | *Ficus cotinifolia* Kunth | 117 |
| Anacardiaceae | *Spondias mombin* L. | 139 | Fabaceae | *Caesalpinia pulcherrima* (L.) Sw.[a] | 110 |
| Moraceae | *Brosimum alicastrum* Sw. | 137 | Sapotaceae | *Manilkara zapota* (L.) Sw. | 110 |
| Solanaceae | *Capsicum annuum* L. | 135 | Bignoniaceae | *Tabebuia* rosea (L.) P. Royen | 108 |
| Malvaceae | *Pseudobombax ellipticum* (Kunth) Dugand | 133 | Araliaceae | *Dendropanax arboreus* (L.) Decne. & Planch. | 104 |
| Moraceae | *Ficus pertusa* L. f. | 132 | Malpighiaceae | *Byrsonima crassifolia* (L.) Kunth | 103 |
| Apocynaceae | *Plumeria rubra* L. | 127 | Fabaceae | *Acacia farnesiana* (L.) Willd. | 102 |
| Fabaceae | *Gliricidia sepium* (Jacq.) Kunth ex Walp. | 125 | Fabaceae | *Phaseolus vulgaris* L. | 102 |

Source: Authors' elaboration based on the systematization of information (2010–2024)
[a]Introduced species

(González et al., 2010); the Official Mexican Standard (NOM) NOM-059-SEMARNAT-2010 (DOF, 2010) and the IUCN Red List of Threatened Species (IUCN, 2016).

A total of 515 plant species were identified as having some extinction risk status, either by one or more of the previously mentioned instances. This underscores the

importance that home gardens play in safeguarding and conserving threatened plant species. For Appendix II of the CITES, 62 species were identified; the Red List of Tree Species of the Cloud Forest in Mexico identified 124 species; the Mexican Official Standard NOM-059-SEMARNAT-2010 found 51 species; and the IUCN Red List of Threatened Species listed 425 species.

## 6.12 Information Gaps

A noteworthy fact that warrants attention, considered as information gaps, is the presence of certain species reported as having "without common name" or "without local name." These instances account for only 2% (30 species) of the total 1452 species documented in home gardens, as shown in Table 6.11. Overall, these information gaps can be attributed to several factors, including methodological issues (indicating that

**Table 6.11** Species from home gardens in south-southeast Mexico that were recorded without a common name

| Species | |
|---|---|
| 1. *Ageratum munaense* R. M. King & H. Rob[a] | 16. *Jasminum fruticans* L.[b] |
| 2. *Alpinia zerumbet* (Pers.) B. L. Burtt & R. M. Sm.[b] | 17. *Kalanchoe laxiflora* Baker[b] |
| 3. *Bursera penicillata* (DC.) Engl.[a] | 18. *Lantana achyranthifolia* Desf.[c] |
| 4. *Carissia macrocarpa* Eckl.[b] | 19. *Leonotis nepetifolia* (L.) R. Br.[b] |
| 5. *Centratherum punctatum* Cass.[b] | 20. *Megaskepasma erythrochlamys* Lindau[b] |
| 6. *Cercocarpus macrophyllus* C. K. Schneid.[b] | 21. *Ocimum carnosum (Spreng.)* Link & Otto ex Benth.[b] |
| 7. *Crocosmia aurea* C. K. Schneid.[b] | 22. *Odontonema tubaeforme (*Bertol.) Kuntze[c] |
| 8. *Dryopetalon auriculatum* (Pappe ex Hook.) Planch.[c] | 23. *Palicourea psychotrioides* (C. M. Taylor & Hammel) C. M. Taylor[b] |
| 9. *Epiphyllum pumilum* (A. Gray) Al-Shehbaz[c] | 24. *Cenchrus clandestinus* (C. M. Taylor & Hammel) C. M. Taylor[b] |
| 10. *Eragrostis hypnoides* Britton & Rose[c] | *25. Plumeria pudica* Jacq.[b] |
| 11. *Euphorbia neriifolia* L.[b] | 26. *Pseuderanthemum carruthersii* (Seem.) Guillaumin[b] |
| 12. *Ferocactus latispinus* (Kunth) Nees[a] | 27. *Scadoxus multiflorus* (Martyn) Raf.[b] |
| 13. *Hippeastrum elegans* (Spreng.) H. E. Moore[b] | 28. *Solandra guttata* D. Don[a] |
| 14. *Huernia macrocarpa* Schweinfurth ex K. Schum.[b] | 29. *Trifolium amabile* Kunth[c] |
| 15. *Jarava ichu*[c] | 30. *Tigridia pavonia* (L. f.) DC.[c] |

Source: Authors' elaboration based on the systematization of information (2010–2024)
[a]Endemic
[b]Introduced
[c]Native

the work is still in progress), a lack of inquiries about the common names from a broader group of species, and/or a conscious choice to exclude them from the study. In our opinion, performing a literature review could help uncover common names for these species. Additionally, based on our field work experience, it is evident that these species likely have common names, as they are utilized by people.

The 30 species listed in Table 6.11 include endemic, native, and introduced species. For the introduced species, names commonly used internationally may be found online. However, in most cases, these names are considered strictly technical and artificial, created by scientists or technicians and assigned through unique correspondence. This is often practiced among horticulturists and zoologists (Gual-Díaz, 2018). In contrast, useful native and endemic species should have established names due to their value; therefore, it is unclear why they do not have registered common names.

One issue encountered is the publication of floristic lists that have not been properly analyzed by botanists. The lack of rigor in classifying the collected plants has significant amount of synonyms, misspellings, and taxonomic misplacement of certain species in these lists. This is exemplified by the series of state floristic lists for the south-southeast states of Mexico (excluding Tabasco and Guerrero), published in the Biocultural Atlas of the Homegardens of Mexico (Atlas Biocultural de Huertos Familiares en México) by Ordóñez (2018).

In the Biocultural Atlas, we identified several nomenclatural inconsistencies in the state or regional species lists. These inconsistencies included (a) the presence of synonyms, where multiple names were used for the same species, and (b) the inclusion of some species without specific punctuation (-sp.-), with non-existent names, or with syntax errors. As a result, these species were excluded from the analysis conducted in this study, leading to a reduction of approximately 30% in the species listed in the Biocultural Atlas. This highlights the need for interdisciplinary research and to verify the validity of the names used in floristic lists.

When comparing the number of plant species in the home gardens reported by Ordóñez (2018) with those found in the present study, the results indicate that the present study exceeded the previous findings by more than 50% in most states or regions. For example, in the Yucatan Peninsula and Chiapas, the increase was more than 100% (Table 6.12). It is important to note that the Biocultural Atlas did not include the states of Tabasco, which ranked first in floristic diversity of home gardens in the present study, or Guerrero, which had the lowest diversity of plants in home gardens.

It is important to highlight the need for accurate scientific rigor, systematization methods, and thorough information search when constructing floristic inventories. These practices will help prevent information gaps about the plant species in home gardens, a very important and valuable agroecosystem in Mexico.

One crucial aspect that we believe should be emphasized in future studies of cultivated plants is the inclusion of intraspecific diversity within species, which is quite rich. This approach would enhance our understanding of the genetic resources developed by peasant populations worldwide. For hundreds and even thousands of years, these communities have been manipulating and selecting plant characteristics that are more beneficial to them.

**Table 6.12** State/region, number of species, and number of studies from the Biocultural Atlas of Homegardens of Mexico (Ordóñez, 2018) and from the present work

| State/region | Number of species in biocultural atlas | Number of studies in biocultural atlas | Number of species in present work | Number of studies in present work |
|---|---|---|---|---|
| Campeche | See Yucatan Peninsula | See Yucatan Peninsula | 571 | 16 |
| Chiapas | 197 | 16 | 438 | 17 |
| Guerrero | Not included | Not included | 174 | 9 |
| Hidalgo | 214 (they report coffee plantations and cornfields) | 15 | Not included | Not included |
| Quintana Roo | See Yucatan Peninsula | See Yucatan Peninsula | 292 | 10 |
| Oaxaca | 245 | 27 | 406 | 26 |
| Tabasco | Not included | | 642 | 16 |
| Veracruz | 242 | 12 | 245 | 22 |
| Yucatan | See Yucatan Peninsula | | 453 | 20 |
| Yucatan Peninsula (Campeche, Quintana Roo, and Yucatan) | 359 | 112 | 731 | 41 |
| Total | 821 | 182[a] | 1452 | 136[b] |

Source: Authors' compilation based on the systematization of information (2010–2024)
[a]The Atlas values may fluctuate in the literature, since we tried to filter out those of a purely ethnographic nature
[b]Unique literature, there are 41 references that deal with more than one state

## 6.13 Final Reflections

The collection and systematization of data on the floristic richness of home gardens in south-southeast Mexico, which comprises 25% of the national territory, highlights the region's heritage. This area boasts the highest biocultural richness in the country and is ranked second in biocultural diversity in the world. Based on this information, we can make the following final reflections:

1. The home gardens in the south-southeast region of Mexico are among the agroecosystems with the highest floristic richness in the country.
2. It is estimated that there are more than 1.7 million home gardens covering over 100,000 ha in this region. These gardens not only provide goods to households and local markets but also hold significant botanical, zoological, ecological, economic, and social importance. This highlights the urgent need to intensify efforts to better understand the quantity and biological richness of Mexico's home gardens.
3. Home gardens are a fundamental component of agroforestry systems in Mexico. Therefore, decision-makers need to incorporate them into public policies. Additionally, more universities, research, and postgraduate institutions should conduct studies on this subject.

4. Furthermore, due to the significant number of native and endemic species cultivated in home gardens, it is necessary to reevaluate the number of domesticated species in Mesoamerica. This evaluation should lead to an update of the national list on agrobiodiversity for subsequent publication by the Mexican Ministry of Agriculture and Rural Development.
5. The great inter-species richness recorded, derived both from literature review and field work, invites scientists and technicians to study this subject in depth.
6. It is important to approach the study of home gardens through multidisciplinary teamwork. This approach will enhance our understanding of home gardens and contribute to developing more effective strategies for identifying, sustainably using, and conserving these natural resources for food, nutrition, food security, and medicine.
7. Given the fact that natural resources in Mexico have utilized natural resources, specifically plants, for hundreds or even thousands of years, and acknowledging their essential role in self-care practices, we urge the Ministry of Health and the Ministry of Social Development in Mexico to work together in a multidisciplinary approach for the study and application of medicinal plants.
8. Recognizing that rural and semi-rural communities have enriched and will continue to enhance the floral diversity of their home gardens, this study emphasizes the need to raise awareness among various sectors of the population. It highlights the importance of these agroecosystems and their cultural and biocultural richness in Mexico.

## References

Aguilar, S. D. (2018). Consideraciones sobre los nombres comunes y los nombres científicos. *Biología Tropical*. https://doi.org/10.15517/rbt.v0i1.35026

Anónimo. (2024). Clima de Oaxaca. https://paratodomexico.com/estados-de-mexico/

Angiosperm Phylogeny Group (APG). (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society, 181*, 1–20. https://doi.org/10.1111/boj.12385

Bermejo, C. (2015). *Los huertos familiares en Coatetelco, municipio de Miacatlán, Morelos, México*. Tesis de Licenciatura. Universidad Nacional Autónoma de México (UNAM), Ciudad de México.

Biblioteca Digital de la Medicina Tradicional Mexicana (BDMTM). (2009). Diccionario Enciclopédico de la Medicina Tradicional Mexicana. Disponible en: http://www.medicina-tradicionalmexicana.unam.mx/demtm/index.html

Boege, E. (2008). *El patrimonio biocultural de los pueblos indígenas de México. Hacia la conservación in situ de la biodiversidad y agrodiversidad en los territorios indígenas*. Instituto Nacional de Antropología e Historia; Comisión Nacional para el Desarrollo de los Pueblos Indígenas.

Caballero, J., Cortés, L., & Martínez-Ballesté, A. (2010). Cap. 8. El manejo de la biodiversidad en los huertos familiares. In V. Toledo (Ed.), *La biodiversidad de México. Inventarios, manejos, usos, informática, conservación e importancia cultural. México*. Fondo de Cultura Económica/ Consejo Nacional para la Cultura y las Artes (pp. 220-234).

Cano-Contreras, E. J. (2015). Huertos familiares: un camino hacia la soberanía alimentaria. *Revista Pueblos y Fronteras Digital, 10*(20). San Cristóbal de Las Casas jul./dic. 2015. https://www.scielo.org.mx/scielo.php?pid=S1870-41152015000200070&script=sci_arttext

Carnevali, G., Tapia, J. L., Duno, R., & Ramírez, I. (2010). *Flora ilustrada de la Península de Yucatán. Listado Florístico*. Yuatán. Centro de Investigación Científica de Yucatán (CICY), 328 p.

Casas, A., Parra, F., Aguirre-Dugua, X., Rangel-Landa, S., Blancas, J., Vallejo, M., Moreno-Calles, A. I., Guillé, S., Tórres-García, I., Delgado-Lemus, A., Pérez-Negrón, E., Figueredo, C. J., Cruse-Sanders, J. M., Farfán-Heredia, B., Solís, L., Otero-Arnaiz, A., Alvarado-Sizzo, H., & Camou-Guerrero A. (2017). Cap. 3. Manejo y domesticación de plantas en Mesoamérica. In A. Casas, J. Torres-Guevara, & F. Parra-Rondinel (Eds.), *Vol. 2. Domesticación en el Continente Americano. Investigación para el manejo sustentable de recursos genéticos en el Nuevo Mundo*. Universidad Nacional Autónoma de México (UNAM)/Universidad Nacional Agraria La Molina (UNALM)/Consejo Nacional de Ciencia y tecnología (CONACYT) (pp. 69–102).

Colín, H., Hernández, A., & Monroy, R. (2012). El manejo tradicional y agroecológico en un huerto familiar de México, como ejemplo de sostenibilidad. *Etnobiología, 10*, 12–28.

CONABIO. (2024). La evolución bajo domesticación. Biodiversidad mexicana. Diversidad natural y cultural. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. Página electrónica: https://www.biodiversidad.gob.mx/diversidad/evolucion-bajo-domesticacion

CONABIO, INIFAP, ICTA, CENTA, DIBIO-MI AMBIENTE, Universidad de Birmingham, & UICN. (2019). Parientes silvestres de cultivos de Mesoamérica.

DGSIAP. (2024). Intención de Siembra y de Cosecha. Dirección General del Servicio de Información Agroalimentaria y Pesquera Acciones y Programas Intención de Siembra y de Cosecha. Página Electrónica: https://nube.agricultura.gob.mx/agroprograma/

Diario Oficial de la Federación (DOF). (2010). Norma Oficial Mexicana NOM-059-SEMARNAT-2010. Protección ambiental—Especies nativas de México de flora y fauna silvestres: categorías de riesgo y especificaciones para su inclusión, exclusión o cambio—Lista de especies en riesgo. [consultada 2017 Enero 17]. http://www.profepa.gob.mx/innovaportal/file/435/1/NOM_059_SEMARNAT_2010.pdf.

Eyzaguirre, P. B., & Linares, O. F. (Eds.). (2004). *Home gardens and agrobiodiversity*. Smithsonian Institution Press.

Gernandt, D. S., & Pérez-de la Rosa, J. (2014). Biodiversidad de Pinophyta (coníferas) en México. *Revista Mexicana de Biodiversidad, 85*, S126–S133.

González, M., Meave, J., Lorea, F. G., & Ibarra, G. (2010). Lista roja de especies de árboles del bosque mesófilo de montaña (BMM) en México. In G. Vargas, O. Vargas, A. Rodríguez, M. Harker, & A. S. Monroy (Eds.), *XVIII Congreso Mexicano de Botánica: la botánica nacional en el bicentenario de la independencia*.

González-Jácome, A. (2007). Agroecosistemas mexicanos: pasado y presente. *Itinerarios, 6*, 55–80.

Gual-Díaz, M. (Coord.). (2018). *Taxonomía de los usos y manejo de la biodiversidad de México para la construcción de sistemas de información*. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. 376 p.

Gutiérrez, L. D. (2003). *Etnobotánica de huertos familiares o solares en el Poblado de Gabriel Esquinca municipio de San Fernando, Chiapas*. Tesis de Licenciatura. Universidad Nacional Autónoma de México (UNAM).

Harlan, J. (1975). *Crops and man*. American Society of Agronomy and Crop Science Society of America.

Hernández, X. E. (1985). *Biología agrícola*. CECSA. 62 p.

Hersch, P., & González, L. (2011). *Enfermar sin permiso. Un ensayo de epidemiología sociocultural a propósito de seis entidades nosológicas de raigambre nahua en la colindancia de Guerrero, Morelos y Puebla. México*. Instituto Nacional de Antropología e Historia (p. 240).

INEGI. (2023a). *Resultados Definitivos del Censo Agropecuario 2022 en el Estado de Guerrero*. Instituto Nacional de Estadística Geografía e Informática. https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2023/CA_Def/CA_Def2022_Gro.pdf
INEGI. (2023b). *Resultados Definitivos del Censo Agropecuario 2022 en el Estado de Oaxaca*. Instituto Nacional de Estadística Geografía e Informática. https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2023/CA_Def/CA_Def2022_Oax.pdf
INEGI. (2023c). *Resultados definitivos del Censo Agropecuario 2022 en el Estado de Chiapas*. Instituto Nacional de Estadística Geografía e Informática. https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2023/CA_Def/CA_Def2022_Chis.pdf
INEGI. (2023d). *Resultados definitivos del Censo Agropecuario 2022 en el Estado de Veracruz*. Instituto Nacional de Estadística Geografía e Informática. https://www.uv.mx/agronomia/files/2022/09/Comunicado-estatal-Ver_CA2022_697.pdf
INEGI. (2023e). *Censo 2022. Unidades de Producción Agropecuaria en Tabasco*. Instituto Nacional de Estadística Geografía e Informática. https://www.inegi.org.mx/contenidos/programas/ca/2022/doc/inf_up_agro_tab_ca2022.pdf
INEGI. (2023f). *Resultados definitivos del Censo Agropecuario 2022 en el Estado de Campeche*. Instituto Nacional de Estadística Geografía e Informática. https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2023/CA_Def/CA_Def2022_Camp.pdf
INEGI. (2023g). *Resultados definitivos del Censo Agropecuario 2022 en el Estado de Quintan Roo*. Instituto Nacional de Estadística Geografía e Informática. https://en.www.inegi.org.mx/contenidos/saladeprensa/boletines/2023/CA_Def/CA_Def2022_QRoo.pdf
INEGI. (2023h). Censo 2022. Resultados Definitivos Yucatán https://www.inegi.org.mx/contenidos/programas/ca/2022/doc/ca2022_rdYUC.pdf
INEGI (2023i). Censo Agropecuario (CA) 2022. https://www.inegi.org.mx/programas/ca/2022/
Instituto Nacional de los Pueblos Indígenas (INPI). (2020a). Atlas de los Pueblos Indígenas de México. Guerrero. Página electrónica: https://atlas.inpi.gob.mx/guerrero-2/
Instituto Nacional de los Pueblos Indígenas (INPI). (2020b). Atlas de los Pueblos Indígenas de México. Oaxaca. Página electrónica: https://atlas.inpi.gob.mx/oaxaca-2/
Instituto Nacional de los Pueblos Indígenas (INPI). (2020c). Atlas de los Pueblos Indígenas de México. Veracruz. Página electrónica: https://atlas.inpi.gob.mx/veracruz-2/
Instituto Nacional de los Pueblos Indígenas (INPI). (2020d). Atlas de los Pueblos Indígenas de México. Chiapas. Página electrónica: https://atlas.inpi.gob.mx/chiapas-2/
Instituto Nacional de los Pueblos Indígenas (INPI). (2020e). Atlas de los Pueblos Indígenas de México. Tabasco. Página electrónica: https://atlas.inpi.gob.mx/tabasco-2/
Instituto Nacional de los Pueblos Indígenas (INPI). (2020f). Atlas de los Pueblos Indígenas de México. Campeche. Página electrónica: https://atlas.inpi.gob.mx/campeche-2/
Instituto Nacional de los Pueblos Indígenas (INPI). (2020g). Atlas de los Pueblos Indígenas de México. Quintana Roo. Página electrónica: https://atlas.inpi.gob.mx/quintana-roo/
Instituto Nacional de los Pueblos Indígenas (INPI). (2020h). Atlas de los Pueblos Indígenas de México. Yucatán. Página electrónica: https://atlas.inpi.gob.mx/yucatan-2/
IUCN. (2016). The IUCN Red List of Threatened Species. Versión 2024-2. https://www.iucnredlist.org
Kirchoff, P. (1943). Mesoamérica: Sus límites geográficos, composición étnica y caracteres culturales. *Acta Americana, 1*, 92–107.
Llorente-Bousquets, J., & Ocegueda, S. (2008). Estado del conocimiento de la biota. In *CONABIO. Capital Natural de México, Volumen I: Conocimiento actual de la biodiversidad*. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad.
Lope-Alzina, D. G., Vázquez-Dávila, M. A., Gutiérrez, C. J. G., Juan, P. J. I., Pedraza, P. R. A., & Ordóñez, D. M. J. (2018). Una propuesta conceptual para abordar la complejidad del huerto familiar. In D. M. J. Ordóñez (Coord.). *Atlas biocultural de huertos familiares en México. Chiapas, Hidalgo, Oaxaca, Veracruz y Península de Yucatán*. Universidad Nacional Autónoma de México (UNAM) (pp. 99–119). Centro Regional de Investigaciones Multidisciplinarias.

Lott, E., & Atkinson, T. (2010). Diversidad florística. In G. Ceballos, L. Martínez, A. García, J. Bezaury, & R. Dirzo (Eds.), *Diversidad, amenazas y áreas prioritarias para la conservación de las selvas secas del Pacífico de México* (pp. 41–52). Fondo de Cultura Económica/Comisión Nacional para el Conocimiento y Uso de la Biodiversidad.

MacNeish, R. (1967). An interdisciplinary approach to an archeological problem. In *The prehistory of the Tehuacan Valley*. University of Texas Press.

Maffi, L. (2005). Linguistic, cultural, and biological diversity. *Annual Review of Anthropology, 34*, 599–617.

Magaña, P., & Villaseñor, J. L. (2022). La flora de México ¿se podrá conocer completamente? *Ciencias, 66*, 24–26.

Magurran, A. E. (1988). *Ecological diversity and its measurement* (p. 179). Princeton University Press.

Mariaca-Méndez, R. (2012). La complejidad del huerto familiar maya del sureste de México. In R. Mariaca-Méndez (Ed.), *El huerto familiar del sureste de México* (pp. 7–97). El Colegio de la Frontera Sur (ECOSUR), Secretaría de Recursos Naturales y Protección del estado de Tabasco.

Mariaca-Méndez, R. (2017). Avances en el estudio de la fauna de los traspatios familiares en el sureste de México. In A. Casas, J. Torres-Guevara, & F. Parra (Eds.), *Domesticación. El Continente Americano. Investigación para El manejo sustentable de recursos genéticos en el nuevo mundo* (Vol. 2, pp. 475–507). Universidad Nacional Agraria La Molina de Perú y Universidad Nacional Autónoma de México.

Mariaca-Méndez, R., González-Jácome, A., & Arias-Reyes, L. M. (2010). *El Huerto Maya Yucateco en el siglo XVI*. El Colegio de la Frontera Sur, Cinvestav-Mérida, Universidad Intercultural Maya de Quintana Roo, Consejo de Ciencia y Tecnología del Estado de Yucatán y Fondo Mixto Conacyt de Yucatán. 180 p.

Martínez, R., & Juan-Pérez, J. I. (2005). Los huertos: una estrategia para la subsistencia de las familias campesinas. *Anales de Antropología, 39*, 25–50.

Mittermeier, R. A., Robles-Gil, P., & Mittermeier, C. G. (1997). *Megadiversity. Earth's biologically wealthiest nations* (p. 501). CEMEX y Agrupación Sierra Madre.

Monroy, R., & Colín, H. (2012). La poliespecifidad de los huertos frutícolas tradicionales. In R. Monroy, R. Monroy-Ortiz, & C. Monroy-Ortiz (Comps.), *Las unidades productivas tradicionales. Frente a la fragmentación territorial* (pp. 43–56). Universidad Autónoma del Estado de Morelos (UAEM).

Morrone, J. (2005). Hacia una síntesis biogeográfica de México. *Revista Mexicana de Biodiversidad, 76*(2), 207–252.

Morrone, J. J., Escalante, T., & Rodríguez-Tapia, G. (2017). Mexican biogeographic provinces: Map and shapefiles. *Zootaxa, 4277(2), 277–279.* https://doi.org/10.11646/zootaxa.4277.2.8

Morrone, J. (2019). Regionalización biogeográfica y evolución biótica de México: encrucijada de la biodiversidad del Nuevo Mundo. *Revista Mexicana de Biodiversidad, 90*(2019), e902980.

Ordóñez, D. M. J. (Coord.). (2018). *Atlas biocultural de huertos familiares en México. Chiapas, Hidalgo, Oaxaca, Veracruz y Península de Yucatán*. Universidad Nacional Autónoma de México (UNAM). Centro Regional de Investigaciones Multidisciplinarias. 424 p.

Ortiz-Sánchez, A., Monroy-Ortiz, C., Romero-Manzanares, A., Luna, C. M., & Castillo, E. P. (2015). Multipurpose functions of home gardens for family subsistence. *Botanical Sciences, 93*, 791–806.

Pulido, M., Pegaza-Calderón, E., Martínez-Ballesté, A., Maldonado, B., Saynes, A., & Pacheco, R. M. (2008). Home gardens as an alternative for sustainability: challenges and perspectives in Latin America. In U. P. De Albuquerque & M. Alves-Ramos (Eds.), *Current topics in ethnobotany research signpost* (pp. 51–80).

Quintero, J. F. (2015). *Evaluación del huerto familiar de Coatlán del Río, Morelos. Tesis de Licenciatura*. Universidad Autónoma del Estado de Morelos (UAEM).

Rzedowski, J., & Calderón de Rzedowski, G. (1997). Fascículo 51. Leguminosae. Subfamilia Caesalpinioideae. In J. Rzedowski & G. Calderón de Rzedowski (Eds.), *Flora del Bajío y de regiones adyacentes*. Instituto de Ecología, A. C. (INECOL). 111 pp.

Secretaría de Agricultura y Desarrollo Rural (SADER). (2023). *Huertos familiares, producción y nutrición para todos*. Secretaría de Agricultura y Desarrollo Rural. México. Página electrónica: https://www.gob.mx/agricultura/articulos/huertos-familiares-produccion-y-nutricion-para-todos

Secretaría de Salud (SSA). (2020). Veinte principales causas de enfermedad Nacional, por grupos de edad. https://epidemiologia.salud.gob.mx/anuario/2020/principales/nacional/grupo_edad.pdf

Secretaría de Salud (SSA). (2021). Veinte principales causas de enfermedad Nacional, por grupos de edad. https://epidemiologia.salud.gob.mx/anuario/2021/principales/nacional/grupo_edad.pdf

Secretaría de Salud (SSA). (2022). Veinte principales causas de enfermedad Nacional, por grupos de edad. https://epidemiologia.salud.gob.mx/anuario/2022/principales/nacional/grupo_edad.pdf

Secretaría de Salud (SSA). (2023). Veinte principales causas de enfermedad Nacional, por grupos de edad. https://epidemiologia.salud.gob.mx/anuario/2023/principales/nacional/grupo_edad.pdf.

Secretaría de Salud (SSA). (2024). Veinte principales causas de enfermedad Nacional, por mes de notificación en los Estados Unidos Mexicanos 2023. Anuario de Morbilidad 1984–2023. Población. https://epidemiologia.salud.gob.mx/anuario/2023/morbilidad/nacional/veinte_principales_causas_enfermedad_nacional_mes.pdf

Smith, B. D. (2006). Eastern North America as an independent center of plant domestication. *Proceedings of the National Academy of Sciences of the United States of America, 103*, 12223–12228.

Toledo, V. M., & Barrera-Bassols, N. (2008). *La memoria biocultural*. Icaria.

Torres-Avilez, W., Méndez-González, M., Durán-García, R., Boulogne, I., & Germosén-Robineau, L. (2015). Medicinal plant knowledge in Caribbean Basin: a comparative study of Afrocaribbean, Amerindian and Mestizo communities. *Journal of Ethnobiology and Ethnomedicine, 11*, 18.

Trejo, I. (2010). Las selvas secas del Pacífico mexicano. In G. Ceballos, L. Martínez, A. García, J. Bezaury, & R. Dirzo (Eds.), *Diversidad, amenazas y áreas prioritarias para la conservación de las selvas secas del Pacífico de México* (pp. 41–52). Fondo de Cultura Económica/Comisión Nacional para el Conocimiento y Uso de la Biodiversidad.

Universidad Nacional Autónoma de México (UNAM). (2022). Provincias biogeográficas mexicanas 2017 [Mapa]. Grupo de Biogeografía de la Conservación, Departamento de Biología Evolutiva, Facultad de Ciencias, Universidad Nacional Autónoma de México; Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO). http://geoportal.conabio.gob.mx/metadatos/doc/html/pbiogmx17gw.html

Vandermarker, A. M. (2006). *Farming, hunting and fishing in the Olmec world*. University of Texas Press. 244 p.

Vavilov, N. I. (1926). *Studies on the origin of cultivated plants*. Institute of Applied Botany and Plant Breeding.

Villaseñor, J. L., & Espinosa-García, F. J. (2004). The alien flowering plants of Mexico. *Diversity and Distributions, 10*(2), 113–123.

White-Olascoaga, L., Juan-Pérez, J. I., Chávez-Mejía, C., & Gutiérrez-Cedillo, J. G. (2013). Flora medicinal en San Nicolás, municipio de Malinalco, Estado de México. *Polibotánica,* no. 35 México feb. 2013.

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# Chapter 7
# Seed Guardians: Indigenous Women Preserving Native Crops




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**Abstract** The practice of traditional agriculture and the conservation of native seeds are crucial components of agroecology, yet they face significant threats from both exogenous factors, such as climate change, and endogenous factors, like the widespread use of improved or genetically modified seeds. In response, indigenous populations have shown resistance to the adoption of industrialized seeds, with one notable example being the group of women known as the "Guardians of the Seeds" in Mitontic, Chiapas. The integration of social capital and local biodiversity knowledge plays a key role in the implementation of conservation-oriented actions. When external actors support these efforts and respect local knowledge and practices, they can strengthen cultural control, foster community organization, and empower indigenous actors to make autonomous decisions, thus reinforcing processes "from within."

From 2019 to 2022, Slow Food International collaborated with local organizations in the Tsotsil municipality of Mitontic to establish the Agroecological Milpa Bastion and provide targeted training focused on native seed conservation. This study aimed to analyze how external support has strengthened the cultural control of the "Guardians of the Seeds" group in Mitontic during two phases of the project: the establishment of the Agroecological Milpa Bastion (2019–2020) and the subse-

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quent strengthening of capacities and networking (2020–2022). The research followed a qualitative approach, using focus groups to gather insights into the community's collective perceptions. Two focus groups were held with women producers participating in the Agroecological Milpa Project.

Among the main findings, it was revealed that the group has successfully established a mud house for storing native seeds from the milpa and has enhanced their production capabilities through agroecological techniques that combine ancestral knowledge with current technical practices. There has been a heightened awareness about the production and consumption of healthy, organic foods, free from agrochemicals, thanks to the implementation of agroecological practices. Finally, significant efforts by the collaborating organizations have led to the recognition of women's work and their inclusion in decision-making processes.

**Keywords** Traditional agriculture · Agroecology · Food sovereignty · Biodiversity conservation

## 7.1 Introduction

The practice of traditional agriculture and the conservation of native seeds are crucial elements in agroecology. However, these practices have been facing threats from exogenous factors, such as climate change, and various endogenous factors, including the preference for agricultural technological packages, a lack of training and technical assistance for small-scale farmers, the use of improved or genetically modified seeds, among others (Goodwin & Gouldthorpe, 2013; Malhi et al., 2021). With respect to the latter factor, indigenous populations have shown resistance to the use of industrialized seeds. Documented cases in countries like Argentina, Colombia, Ecuador, and Mexico illustrate that these groups favour agroecological techniques and native seeds instead (Broccoli & Pardías, 2009; Centro Internacional de Mejoramiento de Maíz y Trigo, 2019; Hernández Vidal, 2019; Torres, 2008).

In Argentina, an informal group of small farmers, self-identified as the "Guardians of the Criollo Seeds," has been working since 2008 to recover two traditional maize varieties, *colorado* and *amargo*, which have historically been cultivated in the province of Santa Fé. This initiative began out of a farmer's concern over the near disappearance of these varieties in the region, which have been largely replaced by dent corn, commonly associated with US production. The seed recovery effort focuses on preserving germplasm within the plantations of small farmers and advancing participatory breeding initiatives led by the farmers themselves. This project views the reintroduction of native seeds as a crucial step towards achieving food sovereignty, as these seeds are vital for family farming. Their cultivation not only sustains traditional agricultural practices but also reduces small farmers' reliance on external markets (Broccoli & Pardías, 2009).

The Free Seed Network of Colombia (RSLC), founded in 1994, is a non-governmental organization focused on environmental and rural issues. It comprises

guardians who leverage traditional agricultural knowledge to resist the intellectual property regimes imposed by large corporations. These corporations, employing advanced technologies, like genetically modified seeds, exert control over genetic resources, often to the detriment of indigenous communities that have historically protected and utilized these resources. In a 2019 study, Hernández Vidal (2019) explored the RSLC peasant collective's resistance to regimes that frame peasantry as a marker of underdevelopment. The study introduced the concept of *epistemic harvesting, which refers to the dynamic processes through which these guardians create new knowledge,* adapt and transform existing knowledge, and promote collaborative spaces. These spaces, established by the network, include national, regional, and local meetings, itinerant schools, agroecological markets, fairs, and similar initiatives. All these efforts are aimed at strengthening collective practices and preserving traditional agricultural systems.

The Seed Guardians Network, founded in 2002 in Ecuador, consists of over 50 seed guardians located across various provinces. This well-structured and expansive network focuses on exchanging organically and sustainably harvested seeds, fostering biodiversity and sustainable agriculture. One of its most significant achievements has been the effective promotion and revitalization of traditional knowledge, which has enabled the network to preserve hundreds of seed varieties while optimizing resources for food and energy production. Among its many initiatives, the network includes projects dedicated to the recovery of traditional varieties of potatoes, corn, cocoa, and other important crops, ensuring their preservation and continued use in local farming practices (Torres, 2008).

The collective known as the *Guardians of the Seeds of Southern Yucatan* (*Káa nán iinájóob* in Mayan) was established in 2003 in response to the devastation caused by Hurricane Isidore, which struck the Yucatan Peninsula. The disaster resulted in the loss of both crops for immediate food supply and seeds for future planting. The collective is composed of Mayan men and women who work the milpa and are deeply committed to preserving the biocultural legacy of this agricultural system, which not only sustains their diet but also embodies their worldview. This network of producers has successfully conserved native varieties of corn and associated crops, ensuring food security and the recovery and preservation of local seed varieties, and the production of high-quality seeds year after year. Their efforts support the health of their communities' lands and culminate in their participation in the Seed Festivals, which celebrates their ongoing dedication to agricultural heritage and sustainability (CIMMYT, 2019).

The common thread connecting these four organizations is their shared mission to protect, conserve, and promote the use of native seeds. This initiative is a crucial response to the ongoing loss of biodiversity, which has become particularly evident since the onset of the Green Revolution in the 1950s. The movement initially aimed at increased agricultural yields, but the situation worsened in the 1990s with the advent of a new Green Revolution that promoted genetically modified organisms (Ceccon, 2008). In Mexico, the loss of agrobiodiversity has been further exacerbated by the commercial changes brought by the North American Free Trade Agreement (NAFTA). The agreement, along with macroeconomic crises in the

1980s, such as falling grain prices, pushed agricultural production towards high-value crops to meet global market demands. As a result, this shift led Mexico to reconfigure its agricultural sector, prioritizing the export of fruits and vegetables (Sandoval Cabrera, 2019). While this focus on high-value crops has boosted economic gains, it has also contributed to the decline of native seeds, undermining rural traditions and the cultural heritage of Mexico's largely indigenous peasant population (Betancur Culma, 2018).

Social capital is understood as a resource composed of various elements, such as trust, reciprocity, forms of social participation, and institutional norms (both formal and informal). When combined with knowledge related to biodiversity, these elements play a vital role in implementing conservation-oriented actions (Hernández-Godoy, 2016), including preserving native seeds. Social capital can arise from the internal dynamics of communities—referred to as "inside-out" interaction. Alternatively, it can come from external stimuli provided by other organizations, known as "outside-in" interaction (Woolcock, 1998). The cases of native seed conservation mentioned above serve as examples of social capital interactions within communities, or "inside-out" interactions. However, the "outside-in" interaction, from external stimuli, can originate from a range of actors, including government initiatives through public policy, academia, organized civil society, and non-governmental organizations.

On the other hand, Bonfil Batalla (1983) introduces the concept of cultural control, defined as the social capacity to make decisions regarding cultural elements. These elements include the following: (1) material elements—either natural or transformed; (2) organizational elements—structured social relations and knowledge systems; (3) symbolic elements; and (4) emotional elements—encompassing shared feelings, values, and motivations. Social projects, even those promoted by external organizations, rely on these cultural elements for their implementation. Native seeds are surrounded by these cultural elements, which help contribute to resistance against their disappearance. These include the possession and use of native seeds (material), participation in community production initiatives (organizational), traditional knowledge linked to ancestral agricultural practices (knowledge), the cosmovision tied to the use of native seeds (symbolic), and the intergenerational significance of their use (emotional).

Cultural elements can be classified as either indigenous or external. Indigenous cultural elements are those inherited as part of a social unit's cultural legacy from previous generations or created, maintained, reproduced, or transmitted by the social unit, depending on the nature of the cultural element. In contrast, external cultural elements form part of a group's living culture but are not produced or reproduced by the group itself (Bonfil Batalla, 1991). In this context, social capital has a dual impact on cultural control. It can strengthen cultural control when external projects respect local knowledge and practices, foster community organization, and empower indigenous actors to make autonomous decisions, thereby reinforcing processes "from within." Conversely, cultural control is weakened when external interventions impose foreign agendas, values, or practices, limit local agency, and create dependency, aligning with dynamics "from outside."

In Mexico, the involvement of external organizations with communities has played a crucial role in promoting the conservation of local agrobiodiversity. One such notable example is the women's group called "Guardians of the Seeds" from Mitontic in the state of Chiapas. With support from local and international non-governmental organizations through the Agroecological Milpa Bastion project, they have become protectors of native crops and have implemented agroecological practices in their production systems.

From 2019 to 2020, Slow Food International collaborated with three organizations—CISERP A.C., COFEMO A.C., and IDESMAC A.C.—in the municipality of Mitontic as part of the project "Slow Food in Chiapas and Yucatán." The primary objective in this area was to establish an Agroecological Milpa Bastion, which was implemented across five localities within the Mitontic Municipality in the state of Chiapas, Mexico (Slow Food, 2020). Later, from 2020 to 2022, Slow Food continued its collaboration with CISERP A.C. through the project "Strengthening Capacities and Networking of Guardians of Diversity in Mexico." In Mitontic, this phase focused on providing targeted training for communities involved in the Agroecological Milpa Bastion. Additionally, it facilitated exchanges between communities to strengthen and consolidate the processes initiated during the first phase. It is worth noting that although both projects had broader objectives and covered other locations, to study the conservation of native seeds, this research focuses exclusively on the Mitontic area.

This study aims to analyze how external support from organizations strengthens the cultural control of the "Guardians of the Seeds" group in Mitontic during two key phases of the project: the establishment of the Agroecological Milpa Bastion (2019–2020) and the subsequent strengthening of capacities and networking (2020–2022).

## 7.2 Methods

### *7.2.1 Study Area*

The municipality of Mitontic is situated between the latitudes of 16°51′ and 16°55′ north and the longitudes of 92°30′ and 92°39′ west, with an altitude ranging from 1500 to 2400 m. It shares borders with the municipality of Chenalhó to the north, Tenejapa to the east, and Chamula to the south. To the west, it borders both Chamula and Chenalhó. This municipality accounts for 0.05% of the state's total surface area and contains 15 localities. In 2020, the municipality of Mitontic had a population of 13,755 inhabitants. Of these, 49.1% lived in moderate poverty, while 49.3% lived in extreme poverty. Among the total population, 87.1% (approximately 12,000 individuals aged three and older) speak at least one indigenous language, making Mitontic predominantly indigenous. The most widely spoken indigenous language

is Tsotsil, used by 11,974 inhabitants, followed by Tseltal, spoken by 5 individuals, and Nahuatl, spoken by 1 person (DATA MEXICO, 2020).

### *7.2.2 Focus Groups*

The research was conducted using a qualitative approach, employing the focus group technique to gain insight into the collective perception of the community's situation. Two focus groups were organized, involving women producers participating in the Agroecological Milpa Project. The first focus group was held in October 2019 in the locality of Tojtic, with nine women participating. The second focus group was conducted in July 2023, involving 11 women producers from the same project. Given that the community predominantly speaks Tsotsil, a translator was present during both sessions to facilitate communication.

### *7.2.3 Dimensions of the Qualitative Analysis*

This study applied an interpretative analysis of the cultural identity appropriation related to the techniques and norms introduced during the Slow Food project workshops and training sessions. Grounded in Bonfil Batalla's cultural control theory, the analysis employed the analytical categories of autonomous culture and cultural appropriation to assess the extent and depth of the appropriation of the elements promoted by the Agroecological Milpa Bastion.

The term "autonomous culture" refers to a social group's capacity to exercise internal decision-making over cultural elements that are specific to the group. These elements are produced, preserved, or transmitted through tradition as part of the group's cultural heritage, without relying on external influences. Control over these cultural elements is entirely internal, reflecting self-sufficiency and independence in their use and reproduction.

Appropriate culture, on the other hand, pertains to the internal decision-making processes related to integrating external cultural elements into the group's activities. In the context of this study, this category highlights how producers adopt new techniques and knowledge shared in the project's workshops. The participants' engagement in these activities demonstrates their willingness to incorporate and adapt external innovations. Over time, these appropriated elements may evolve into part of the group's autonomous culture as members gain the capacity to produce, reproduce, and sustain these innovations independently (Bonfil Batalla, 1991).

## 7.3 Agroecological Milpa Bastion (2019–2020)

The "Slow Food in Chiapas and Yucatán" project, implemented in the Mitontic region from 2019 to 2020, was designed with a dual emphasis on territorial governance and a gender-sensitive approach. Supported by local organizations with extensive experience and complementary strategies tailored to the region's specific challenges, the project aimed to empower communities through inclusive and participatory processes. A central initiative was the creation of the Municipal Women's Council, comprising representatives from various localities who were selected to participate in workshops and meetings. This council provided women with a platform to actively engage in decision-making and shape key aspects of the project.

Training sessions organized as part of the initiative covered a range of interconnected themes, including women's empowerment through a gender perspective, the application of agroecological techniques in managing milpa systems, and the establishment and administration of critical community resources such as a seed bank and the Municipal Women's House.

Workshops incorporating a gender perspective were conducted to promote women's rights within the territory and to empower them as producers. These sessions aimed to help women recognize and value their active participation in productive activities—such as planting, irrigation, and harvesting—while also acknowledging their essential roles in household and caregiving responsibilities. The training emphasized the critical importance of women's contributions to the milpa system, particularly in preserving native seeds.

However, deeply rooted *machismo* within the municipality continues to undermine both the value of women's work and their rights. During the focus group data collection, it was essential to first inform the men in the community of the purpose of the researchers' presence. Once this step was completed, permission was granted to conduct the focus group with the women producers participating in the project.

According to local informants, it is usual that any external visitor must introduce themselves and explain the reason for their visit.

One of the project's pillars was the gender perspective, given the urgent need to empower women producers within the community, as reported by a collaborator from one of the local organizations participating.

> So, within that participation, women who water and care for the crops have roles in planting and harvesting that are not valued. I will give you an example: a company arrives and tells the men, 'We will buy your kilos of corn for a certain price.' The men earn more because the work of women and children is not considered. When they go to work, they participate in planting and harvesting, and they bring their families to work for free because it is unpaid work for women, girls, and boys, which seems like fair treatment, but it is not. This training programme, therefore, addresses the importance and relevance of women's work within the milpa system for seed conservation, because if we do not start from the global to the local, it is very difficult.

### 7.3.1 Autonomous Culture in the Agroecological Milpa Bastion

The characteristics of the autonomous culture identified among participants of the Slow Food project of Mitontic are the cultivation of indigenous seeds and the sharing of surplus production from their milpas. The crops grown by the participants have remained largely unchanged in terms of diversification since the project's implementation, as they continue to cultivate what they have always grown. One participant noted, "Yes, we've had them, we've always grown them."

It is worth mentioning that although crop diversity did not increase during the project, producers acquired knowledge of alternative production methods. The conservation of native seeds is a common practice in traditional farming systems such as milpa, as the genetic variability of these species allows them to adapt. Producers conserve crops that can be used for their consumption and potentially for future sale (Álvarez, 1996). Table 7.1 shows the classification of seeds that producers have chosen to store in the mud house.

In the future, the producers are open to cultivating other indigenous seeds, recognizing the importance of growing indigenous crops because of their adaptability to local conditions:

> We would like to grow other types of vegetables, other types of food, to complement what we are already growing, but which are native to our region, so that we can adapt in terms of climate and food diversity, and we are willing to learn.

Currently, the farmers' milpa production primarily serves their own consumption. However, in addition to increasing the diversity of their crops, the farmers also expressed an interest in marketing their products in the future. They understand that

**Table 7.1** Classification of varieties and races chosen for seed bank

| Maize | Beans | Squash | Legume | Tomato |
|---|---|---|---|---|
| • White maize *(sakil ixim)*<br>• Yellow maize (*k'anal ixim)*<br>• Red maize *(tsajal ixim)*<br>• Black maize *(ik'àl ixim)* | • Red bean *(tsajal chenek)*<br>• Black bean *(ik'al chenek)*<br>• White bean *(sakil chenek)*<br>• Pinto bean *(t'sirim chenek)*<br>• Botil bean or red-flowered bean *(botil chenek)*<br>• White-flowered bean or white-flowered bean *(ibes chenek)* | • White chilacayote (*sakil mail)*<br>• Green chilacayote (*yaxal mail)*<br>• Striped or painted chilacayote *(pinto mail)*<br>• Yellow chilacayote amarillo (*k'antzu mayil)*<br>• White green chilacayote blanco verde (*chij chon)*<br>• Yellow squash *(ch'um)* | • Peas<br>• Abbas<br>• Wheat | • Tree tomate[a] *(k'anal chichol)*<br>• Green tomato *(yaxal chichol)*<br>• Red tomatoes *(tsajal k'ox chichol)* |

Note: the name is presented in English and Tsotsil

[a]Native to the region, it has a thick skin and only grows in the milpa

this decision would require a collective discussion involving both producers and facilitators from local organizations.

> A decision [with everybody] is being made to produce tree tomatoes in the long term, to produce them in the field and perhaps to produce them in other places to have a large production area and increase production. At the moment it is for the family's own consumption and for the animals in the backyard, and in the future the commercialization of the maize. Currently, the main focus of the Baluarte and Slow Food project is the maize field. Although it would be a very good initiative.

The women involved explained that they do not typically exchange the products from the milpa, as they feel there is no need for a system of giving and receiving. However, they do share their surplus with other women, especially those not participating in the Slow Food project. They believe that without the knowledge of proper crop management, such as that provided by Slow Food, their crops are at risk of failing:

> In reality, we don't exchange maize or vegetables or any other food, but sometimes when we have enough vegetables, we give them away [to close friends and relatives] because we know that the others sow them, but they die [crops] because of the little care they give them. Because we participate [they are Slow Food beneficiaries], we already know how to take care of it, the others don't, the women from outside [those who are not Slow Food beneficiaries] don't know how to take care of it.

### *7.3.2 Appropriate Culture in the Agroecological Milpa Bastion*

The Slow Food project in the municipality of Mitontic has introduced strategies that represent elements of an appropriate culture. These include training and technical assistance in agroecological practices, as well as the construction of a mud house that serves as both the Municipal Women's House and a Seed Bank.

The appropriate culture can be observed among the participants as they apply the new knowledge acquired during the project for planting in the milpa. They report that the information acquired through workshops has helped them improve their maize cultivation practices, such as making fertilizer from herbal mixtures, creating compounds for fumigating the maize field using chilli, zote soap and lime, and selecting the right seeds.

> Through these workshops, we learned how to make these products, because before the workshops, such as the one on crop fumigation, we did not know how to make these products to care for the maize fields and vegetables. In this way, we have learnt other ways of caring for our crops.

The technical support provided to project participants and their involvement in the workshops have increased awareness of the importance of certain agroecological aspects of production. For example, the producers expressed a preference for using native plants, as they adapt better to the climate. They are also now more

mindful of soil care; they avoid burning maize stalks and instead use them as fertilizer:

> Well, this year in particular we are working on the maize and what is to come, because at the moment we are collecting the maize stalks so that they can rot in the fields for fertiliser. We have learnt a lot. Before we didn't do that, we used to burn the stalks maize, so the soil is not fertile, so now we are starting to do that and the quality of the nutrients is starting to improve, we started this year.

The participants noted that the knowledge gained from the workshops enabled them to understand the benefits of eating healthy, agrochemical-free food produced in the community. As a result, they have increased their production by applying better planting practices in the milpa, unlike other women in the community who do not attend the workshops and lack knowledge of agroecological techniques.

> Before the workshops, the maize (bushes) came out small and they did not have good maize. Now we have seen that the maize (bushes) is very big. We think there will be plenty this year.

Regarding the mud house, also known as Municipal Women's House and Seed Bank, its construction was facilitated through community organizing processes. A committee was set up with the involvement of both men and women from the community, and the municipality was kept informed of all activities. During the design phase, dialogues were held with women leaders to incorporate elements and modifications according to the needs of women producers.

However, challenges emerged throughout the process, particularly concerning male dominance within this space, which can hinder collaboration with women. Despite these difficulties, especially given the prevailing community custom of women not participating or remaining silent, notable advancements were made. Women leaders have taken on roles as facilitators, bringing the opinions and suggestions of other women to the committee. This has begun to transform community processes by incorporating a gender perspective. This dynamic reflects signs of an appropriate culture, promoted by local organizations, that values women's work and includes them in decision-making processes.

## 7.4 Strengthening of the Capacities and Networking (2020–2022)

Between 2020 and 2022, the organization CISERP A.C. conducted several activities within the framework of the Agroecological Milpa Bastion project in the Mitontic locality. These activities aimed to strengthen the organization at both the community and inter-community levels. One notable initiative was a farmer-to-farmer exchange tour organized in the municipality of Teopisca, which promoted collective learning and the creation of networks among producers. Key activities included the annual collection and exchange of native seeds among producer members of the project, an important effort to conserve local biodiversity. Additionally, a

comprehensive technical capacity program was also implemented, focusing on native seed conservation, agroecological milpa production, and the production and use of natural fertilizers and insecticides for maize and fruit crops.

### *7.4.1 Autonomous Culture in the Strengthening of the Capacities and Networking Project*

The characteristics of autonomous culture identified in the second project include the conservation and rescue of seeds, as well as the revaluation of traditional knowledge and practices. Within the framework of the bastion, there is a strong awareness of diversifying products and production systems, which is perceived alongside the defence and rescue of seeds as integral to agricultural activities. As one participant pointed out:

> With the [trainers] we work in the strawberry area, but we also work in the field, defending the yellow seed. [...] we are sowing again to save the seed, in the milpa, where we also have vegetables, maize, beans and pumpkin.

The project has also promoted conservation through the revaluation of traditional practices and knowledge. For example, one participant said: "*I used to watch my parents saving seeds in a pot. They taught us to save them, so they don't get stung. I don't want to buy seeds.*"

The revaluation of traditional knowledge in the context of the Agroecological milpa bastion was evident. As one participant echoed this:

> When it's the first sowing, when the seeds come out, we hang them up, as our grandparents taught us, we wait for them to dry, we thresh them and we put them in a barrel, because that's what we eat all year round.

Another participant also confirmed the importance of revaluing grandparents' knowledge:

> My grandfather had several pieces of knowledge, for example he used to put higuerilla or ocote resin on the seeds and that made the animals stay away because they felt the bitter taste and would not eat the seeds and that was how it was, I learned to work like that and when they went to save their seeds they put them in the kitchen, hung them up [the cobs]. When it was time to sow, they would take the cobs down, peel them and look to see if there were any little animals like weevils or any other animals that could eat or nibble the seed and then the seed could be sown, cured and sown again, that's how my parents worked.

Producers also recognize the importance of saving and rescuing seeds for replanting in the next sowing cycle. They often compare the quality and yield of native seeds with those of industrial seeds, demonstrating the value they place on native seeds: "*The seeds we save we can replant and save for the next cycle. The ones you buy will only give you one plant or one grain of maize. That's why we want our seeds, to save and replant.*"

### *7.4.2 Appropriate Culture in the Strengthening of the Capacities and Networking Project*

At this stage of the project, producers are emphasizing the incorporation of agroecological and organic knowledge as an alternative to using agrochemicals:

> We have learnt to soak the seeds in garlic, and when they are sown, the seeds are no longer taken away by the animals. You can also boil the fig tree in a big pot and fumigate it with pumps to prevent the pest. This is what we have learnt.

One participant highlighted the role of the organization CISERP A. C. in facilitating this exchange and promoting clean and healthy food through agroecological innovations:

> I realized that we put a lot of chemicals in the food, in the corn, in the cornfield, thanks to [CISERP A.C.] they came to teach us organic fertilizer, like sheep manure and chicken manure, I use it for my vegetables, now I have a lot of vegetables. With chemicals it is no longer natural food. I am very grateful to the organizations [...] they taught us how to make an organic insecticide.

Furthermore, another participant acknowledged the innovations in preparing furrows for planting: "*The furrows were made vertically, but in the trainings, we made a barrier so that the fertility of the soil is not lost... also now the chicken manure, we use it as fertilizer.*" One producer pointed out the benefits of innovation in agroecological techniques learned after the training:

> What we see now of how we prepare the land is better than what we did before, it is different because what we do every year is to arrange the stubble in the form of a terrace so that the water does not wash away the soil, I see that it has improved [the system].

## 7.5 Conclusion

The cultivation of native seeds is one of the most important elements of the autonomous culture of the Mitontic participants and is closely linked to the Agroecological Milpa Bastion. The participation of seed guardians in the Slow Food Project strengthens the group's cultural control by integrating traditional practices within a framework of community participation and a gender perspective. On the one hand, the conservation and use of native seeds, the transfer of surplus production to other women, and the revaluation of traditional knowledge and practices are evidence of the continuity of an autonomous culture that keeps the local agricultural identity alive.

The elements observed in the project's development align closely with the concept of epistemic harvesting, as proposed by Hernández Vidal (2019). This framework encompasses the dynamic processes of knowledge creation, adaptation, and transformation, alongside the promotion of collaborative spaces. For example, the project actively fostered collaborative spaces, evidenced by the successful

farmer-to-farmer exchange tour organized in Teopisca. Furthermore, the entire initiative reinforced the processes of knowledge revaluation, such as the revaluation of traditional agricultural practices and knowledge by the informants.

On the other hand, the training and technical support provided by the organizations involved have enabled participants to acquire innovative knowledge, such as the production of natural fertilizers, soil management practices, and ecological spraying methods, which the women producers have adapted to their farming systems, thus reinforcing an appropriate culture.

The construction of the Municipal Women's House and Seed Bank symbolizes a tangible space for consolidating progress, despite the challenges posed by male control and traditional gender dynamics. The active involvement of women leaders, along with their ability to channel the group's needs and proposals into decision-making processes, demonstrates a shift towards a more inclusive and participatory model. These initiatives not only value women's work but also promote their role as guardians of biodiversity and community leaders, consolidating a cultural control that balances the preservation of traditions with the incorporation of innovations needed to face current challenges.

The seed guardians of Mitontic have become aware of the importance of consuming and producing good, healthy food, free of agrochemicals, through the implementation of agroecological practices. Supported by external organizations, the project is an element of social capital that contributes both to the conservation of important biological resources, such as native seeds, and to women producers acting as agents of change. This promotes an agricultural model that combines tradition with innovation, positioning women as leaders in decision-making and in promoting practices that ensure community resilience in the face of agricultural and climatic challenges.

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## References

Betancur Culma, K. (2018). *Perdida de identidades campesinas debido a la desaparición de semillas nativas: El caso del maíz cucaracho y la familia Arias de la vereda El Viento en Barbosa, Antioquia en el año 2018*. Corporación Universitaria Minuto de Dios.

Bonfil Batalla, G. (1983). Lo propio y lo ajeno: Una aproximación al problema del control cultural. *Revista Mexicana de Ciencias políticas y sociales, 27*(103).

Bonfil Batalla, G. (1991). La teoría delcontrol culturalen el estudio de procesos étnicos. *Estudios sobre las Culturas Contemporáneas, 4*(12), 165–204.

Broccoli, A., & Pardías, S. (2009). El rescate de semillas como aporte a la Soberanía Alimentaria. Descripción de una experiencia de conservación de maíz con agricultores familiares santafesinos. *VI Jornadas Interdisciplinarias de Estudios Agrarios y Agroindustriales*. Centro

Interdisciplinario de Estudios Agrarios (CIEA) del Instituto de Investigaciones de Historia Económica y Social de la Facultad de Ciencias Económicas de la Universidad de Buenos Aires y Otras.

Ceccon, E. (2008). La revolución verde tragedia en dos actos. *Ciencias, 1*(91) https://www.redalyc.org/pdf/644/64411463004.pdf

Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT). (2019). Los Guardianes de las Semillas del Sur de Yucatán. https://idp.cimmyt.org/los-guardianes-de-las-semillas-del-sur-de-yucatan/

DATA MEXICO. (2020). Mitontic: Economía, empleo, equidad, calidad de vida, educación, salud y seguridad pública | Data México. https://www.economia.gob.mx/datamexico/es/profile/geo/mitontic#population-and-housing

Goodwin, J., & Gouldthorpe, J. (2013). Small farmers, big challenges: A needs assessment of Florida small-scale farmers' production challenges and training needs. *Journal of Rural Social Sciences, 28*(1) https://egrove.olemiss.edu/jrss/vol28/iss1/3

Hernández Vidal, N. (2019). La cosecha epistémica: Un análisis de la praxis epistémica de los guardianes de semillas en Colombia. In R. Casas & T. Pérez-Bustos (Comp.), *Ciencia, Tecnología y Sociedad En América Latina: Las miradas de las nuevas generaciones*.

Hernández-Godoy, V. (2016). El capital social para la conservación de biodiversidad. Dos casos de estudio en la Selva Lacandona [El Colegio de la Frontera Norte]. https://www.colef.mx/posgrado/wp-content/uploads/2016/12/TESIS-HernándezGodoy-Virginia.pdf

Malhi, G. S., Kaur, M., & Kaushik, P. (2021). Impact of climate change on agriculture and its mitigation strategies: A review. *Sustainability, 13*(3), 1318. https://doi.org/10.3390/su13031318

Sandoval Cabrera, S. V. (2019). El campo mexicano: La estrategia neoliberal y la propuesta del nuevo gobierno. *Economía Informa, 415*, 107–116.

Slow Food. (2020). Las Mujeres de Chiapas Protectoras de La Milpa. https://www.slowfood.com/es/blog-and-news/las-mujeres-de-chiapas-protectoras-de-la-milpa/

Torres, O. (2008). Los guardianes de semillas: Una red de agroecología. *Letras Verdes, 1*, 21–22.

Woolcock, M. (1998). Social capital and economic development: Toward a theoretical synthesis and policy framework. *Theory and Society, 27*(2), 151–208. https://doi.org/10.1023/A:1006884930135

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# Chapter 8
# Cultural Appropriation of a Productive Project Among Indigenous Women in Chiapas, Mexico

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**Abstract** The state of Chiapas is known for its rich biodiversity and cultural heritage, yet it faces significant socioeconomic challenges, with over two-thirds of its population living in poverty. This situation has prompted the involvement of NGOs and academic institutions in supporting traditional knowledge and sustainable practices among indigenous communities. Slow Food International (SF) has been a key actor in promoting the agroecological production and commercialization of corn tostadas, which are considered a *baluarte* or bulwark, to preserve biocultural heritage and empower local producers. SF's initiatives include capacity-building workshops for women in three municipalities of Chiapas: San Cristobal de las Casas, Comitán, and Teopisca. The initiatives have strengthened self-employment opportunities, fostered knowledge exchange, and supported traditional food systems.

This study evaluates the cultural appropriation of the *baluarte* using Bonfil Batalla's (1991) cultural control theory. To achieve this objective, the evaluation incorporated qualitative methods, such as focus groups and in-depth interviews. Data analysis was carried out using the AtlasTi software.

The results show that SF's actions have been aimed at promoting and preserving the traditional milpa system to maintain the gastronomic identity of Chiapas. These efforts were carried out, taking into consideration the participants' cultural aspects,

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which consequently led to a successful appropriation of new capacities and technologies for the production of this traditional product, which, in turn, has helped them to improve its transportation and commercialization. In conclusion, the realization of social projects should take into account a region's cultural dimension in order to achieve a successful appropriation among local participants.

**Keywords** Cultural appropriation · Indigenous woman · Corn tostada · Cultural bulwark

## 8.1 Introduction

The state of Chiapas is rich in biodiversity, landscapes, and ecosystems, placing it among the top four biodiverse states in Mexico. However, it also has one of the highest poverty rates in the country, with 3,838,000 people living in poverty, which accounts for 67.4% of its population (Dirección de Información Geográfica y Estadística; Subsecretaría de Planeación y Comité Estatal de Información Estadística y Geográfica de Chiapas, 2023). This situation has drawn the attention of non-governmental organizations and academic institutions to conduct research on local traditional knowledge and the surrounding habitat. In Chiapas, small-scale agriculture and biodiversity management are primarily carried out by local communities.

Slow Food International (SF) is a global grassroots non-profit association dedicated to promoting good, clean, and fair food for everyone. It is among the organizations interested in promoting the production and consumption of traditional food, especially that derived from the *milpa* and home gardens. SF has collaborated with other organizations and academic institutions in Chiapas. In collaboration with groups and civil associations such as Camadds, Clan Sur (structured by Ciserp A.C., Cofemo A.C., and Idesmac A.C.), and Ecosur, it has developed a project centred on the *milpa* system, known as the *baluarte* or bulwark. The project aims to increase the availability of locally grown corn through agroecological practices, safeguarding agricultural and gastronomic traditions, and fostering the transmission of traditional knowledge. This project is divided into two components: i) corn tostada and ii) seed guardians. This document focuses on the first component.

The corn tostada group consists of indigenous women from the communities in Comitán, Teopisca, and San Cristóbal de las Casas. Data on the population of these municipalities highlight poverty as a pervasive issue, particularly in regions with a significant Indigenous population. These findings underscore the importance of targeted interventions that address the intersection of both cultural and structural factors. Efforts should prioritize enhancing access to resources that promote sustainable livelihood opportunities, ensuring that such initiatives are culturally sensitive and responsive to the specific needs of marginalized communities (see Table 8.1).

The participants of this group produce and sell corn tostadas. The women participating have attended various activities and workshops related to the SF project. As a result of these initiatives carried out within the framework of the project, the

**Table 8.1** Characteristics of the population in the municipalities: San Cristóbal de las Casas, Teopisca, and Comitán de Domínguez

| | San Cristobal de las Casas | Teopisca | Comitán de Domínguez |
|---|---|---|---|
| Total population | 215,874 | 49,499 | 166,178 |
| Women population | 113,582<br>53% | 25,555<br>52% | 86,738<br>52% |
| Indigenous population | 103,865<br>48% | 26,366<br>53% | 12,050<br>7% |
| Population in poverty | 138,106<br>64% | 38,906<br>78% | 115,746<br>69% |

Source: Self-made with information from Dirección de Información Geográfica y Estadística; Subsecretaria de Planeación y Comité Estatal de Información Estadística y Geográfica de Chiapas (2023)

findings suggest significant support for the work of women tostada producers and other local producers from the region in various states across the country. This has enabled the participants to adopt different techniques and recipes for preparing corn tostadas, with the aim of strengthening their commercialization.

This chapter presents the findings of the research carried out on the impacts of the SF project on the group of women tostada producers it supports. It begins by outlining the theoretical framework, which draws on Guillermo Bonfil Batalla's (1991) cultural control theory, in order to understand how local actors manage decision-making over their cultural resources within development initiatives. This framework provides the conceptual basis for examining processes of cultural appropriation, negotiation, and autonomy within the project's implementation. The following section details the theoretical framework followed by the methods employed in the study.

Subsequently, the main achievements and actions undertaken by the project are outlined, which include the standardization of the tostada-making process, with the introduction of different flavours, enhanced techniques of better transportation, and the incorporation of ecotechnologies in tostada preparation. The project also emphasized the development of a business plan, marketing strategies, and product commercialization. Finally, the categories of analysis derived from the theoretical framework are described, and the chapter concludes with a discussion of the study's main findings.

## 8.2 Theoretical Framework: Cultural Control Theory

This study applied Guillermo Bonfil Batalla's (1991) cultural control theory, in order to analyse the dynamics of cultural appropriation among the group of women participating in the tostadas' bulwark initiative. The cultural control theory helps to explain how social groups manage their decision-making capacity regarding issues that impact their own culture. From this perspective, cultural control serves as an

analytical axis to understand the dynamics of appropriation, imposition, or alienation that emerge in contexts where institutional interventions take place—particularly those which are perceived as external to the social groups involved.

Among the fundamental concepts of this theory is the notion of culture. Bonfil defines it as the set of material, social, and symbolic elements that make possible the existence and reproduction of a given social group. These elements are not static; rather, they include practical resources, knowledge, norms, institutions, technologies, and meanings that guide collective action. Therefore, culture is understood as a social construction that implies both relationships among groups and the distribution of power over decision-making and cultural elements.

Similarly, a social group is defined by a shared system of meanings and a common historical experience. In the context of Indigenous peoples, such as those in Chiapas, these groups maintain a social organization that has allowed the intergenerational transmission of traditional knowledge and practices related to territory, agriculture, food, and other aspects that form part of their worldview. Another key concept is identity. Bonfil argues that identity is shaped by the awareness a group has of itself in relation to others. He emphasizes that identity is not a cultural essence but an ideological position expressed through social practice—it is the way a collective asserts its belonging and difference in relation to other groups.

Once these basic concepts are established, Bonfil Batalla introduces the notion of cultural control as the core of his theory. This concept refers to the effective capacity of a social group to make decisions about the cultural elements it uses, produces, or transforms. In every society, there are own elements—those originated and controlled by the group—and external elements, introduced by others. Likewise, decisions can be their own (made by the group) or external (imposed from the outside).

The combination of the origin of cultural elements and the nature of decision-making gives rise to four spheres of cultural control:

(i) Autonomous culture, where both elements and decisions are internal, representing the highest degree of cultural control
(ii) Appropriated culture, which combines external elements with internal decisions, implying the adoption of external innovations through the agency of the group
(iii) Alienated culture, where internal elements are governed by external decisions, which occurs when other actors define the use or meaning of local cultural assets
(iv) Imposed culture, where both elements and decisions are external, representing the maximum loss of cultural control

This perspective is particularly useful for analysing processes of interaction between culturally differentiated groups in which power asymmetries exist, such as those between Indigenous communities and external organizations. In this context, the struggle for cultural control is reflected in the capacity to make decisions regarding traditional knowledge, territorial land use, agricultural technologies, and other dimensions of collective life.

Interventions carried out by NGOs or international institutions are often justified in the name of preserving biocultural heritage or promoting sustainable development. However, in practice, they may generate dynamics of cultural alienation or impositions if communities do not actively participate in the decision-making processes regarding the cultural elements involved, as well as the traditional processes that sustain them. Conversely, when local actors take the lead in these processes and reinterpret external knowledge through their own cultural logic, a process of cultural appropriation—which Bonfil identifies as appropriated culture—takes place; it positively reinforces both autonomy and cultural continuity.

In this context, the bulwark of corn tostada initiative promoted by Slow Food International (SF) seeks to strengthen the traditional agroecological system of the milpa and preserve the local gastronomic identity. From the perspective of the cultural control theory, this intervention can be understood as a negotiation of cultural control between the international organization and the participating communities.

On the one hand, SF introduces external elements, such as new marketing channels, preservation technologies, and capacity-building methodologies. These elements are part of the global food culture and of the 'biocultural heritage' discourse, frequently promoted by international institutions. On the other hand, decisions on how to internalize and utilize these elements—at least to some extent—fall on the local producers themselves.

When participating women reconfigure technical knowledge and combine it with traditional understandings of maize, they are exercising internal collective decision-making over external elements—a form of cultural appropriation. This situation reflects a positive form of cultural control, as it allows the incorporation of innovations without losing cultural autonomy and continuity.

Nevertheless, it is also necessary to consider potential zones of cultural alienation. For example, when the value of the product—as a 'baluarte' or 'bulwark'—is defined according to the criteria of international organizations or markets, rather than by the communities themselves, local identity risks being reconfigured and coopted to fit external expectations of authenticity or discourses.

Thus, the theory of cultural control provides a framework for assessing the balance between internal and external decision-making and for determining the extent to which the cultural appropriation promoted by SF constitutes an emancipatory process or a subtle form of cultural dependence. The main contribution of Bonfil Batalla's theory lies in positioning culture as a field of power, within which social groups contest the right to decide over their own cultural destiny. This perspective transcends folkloric or essentialist understandings of culture by conceiving it as a dynamic process of appropriation, resistance, and transformation.

In analysing contemporary development or cooperation initiatives, the notion of cultural control helps to distinguish between symbolic participation and real autonomy. While many interventions formally acknowledge 'cultural diversity', few ensure that communities maintain genuine decision-making power over the cultural elements involved.

In today's context, marked by globalization, international NGO networks, and cultural commodification, where the boundaries between the 'internal' and the

'external' have become increasingly blurred, Bonfil's cultural control theory presents certain limitations—as it was formulated within the framework of Mexican anthropology in the 1970s and 1980s, with emphasis on state—Indigenous relations—however, we consider that it remains an analytically relevant theoretical and methodological tool for this case study.

## 8.3 Methods

This study employs a qualitative approach, utilizing ethnographic techniques to examine the activities and experiences of a group of women toasters within the framework of the SF project in Chiapas, developed under the milpa agroecological system. The research is grounded in a literature review of activity reports from the project and incorporates data collected across multiple stages, specifically between 2019 and 2023. It is worth noting that the group's activities were interrupted during the 2020 SARS-CoV-2 health emergency, which resulted in the suspension of many communal efforts.

Data collection methods included semi-structured interviews with key informants and focus groups with the women toasters. The focus groups aimed to capture participants' collective perceptions regarding various aspects of the Slow Food project. This approach facilitated an in-depth exploration of selected themes and challenges related to its implementation and operation, as shared by the women in the toasters group. This collective discussion provided valuable insights into the group's shared experiences and collective identity, which may not have been apparent through individual interviews alone.

Data triangulation was achieved by utilizing multiple sources of information, which enhanced the robustness and credibility of the findings (Badilla, 2006). The data analysis process began with transcribing recordings from the focus groups and in-depth interviews. Following the procedures outlined by Hernández-Sampieri et al. (2014) and Chia (2009), the analysis progressed through an initial exploration of the data, followed by its organization and identifying patterns. This included recognizing recurring themes, relationships, and characteristics of people, objects, and events (Bogdan & Biklen, 2003; Creswell, 2009).

The data were coded and categorized, enabling systematic interpretation and explanation of the research problem. This approach also facilitated the identification of data saturation and repetitive themes, contributing to the depth and reliability of the study's findings. Through an interpretive analysis grounded in the theory of cultural control as formulated by Bonfil Batalla (1991), this study examines the appropriation of techniques and standards introduced in workshops and training courses, with particular attention to their incorporation into the groups' cultural identity. This approach employs the analytical categories of autonomous culture and cultural appropriation to assess the extent and depth of incorporating elements from the SF.

As previously mentioned, the concept of autonomous culture denotes the capacity of a group to make internal decisions regarding cultural elements that are inherently their own—whether through their production and preservation by tradition or as pre-existing heritage—thereby signifying an absence of external dependency over such cultural elements. In contrast, cultural appropriation pertains to the internal decision-making processes involved in assimilating externally introduced cultural elements into the group's productive activities.

In this regard, the participation of informants in the workshops underscores their agency in adopting new techniques. Over time, such appropriations and innovations may become part of a group's autonomous culture as they develop the ability to produce and reproduce these elements independently, thereby embedding them into their cultural repertoire.

## 8.4 Standardizing the Preparation of *Tostadas*

One of SF's main objectives is to standardize products for commercialization, as this is necessary to meet the needs of transporters and patrons. With this in mind, a group of women tostada makers decided to modify their traditional recipes in order to better align with market demands. This initiative involved collaboration with academics from the University of Sciences and Arts of Chiapas (UNICACH), who, in partnership with the Tostixim group, held workshops to improve the tostadas. The standardization process consisted of determining a recipe that all participants could use, as well as providing the necessary tools and techniques to ensure that the tostadas have the appropriate physical characteristics for packaging and transportation for commercialization.

During the workshops, participants exchanged their traditional knowledge on improving the tostada-making process through open dialogue. According to a participant, 'We exchanged opinions, which was the basis of the standardization'.

This traditional knowledge, passed down through generations within families, has now become part of the recipe for producing these products, thanks to the exchanges among participants. For example, one participant expressed, 'I learned from my mother. My mother makes tostadas, and I learned from her'.

Moreover, the standardization process revealed that the tostadas must meet specific characteristics for commercialization. One participant describes it as follows:

> We started to make the shipments and saw the need to be able to do what was necessary to flatten [the tostadas]. It was then that I began to flatten the tostadas, by using the techniques [shared by] the colleagues who already knew how, because that way we were both teaching and learning from each other.

To achieve this objective, traditional knowledge regarding the processes of making tostadas, using traditional tools and practices, has been combined. This ensures that the tostadas retain their artisanal characteristics while also meeting the homogeneous attributes required by market demands.

It is worth mentioning that during the standardization process, the participants showed enthusiasm and motivation to continue cooperating with one another. This has positively impacted their collective efforts, including activities such as visits to the homes of the participants:

> We worked in a group at Doña Elena's house. [...] the majority said that they felt comfortable working [in each other's homes]. Because there was dialogue, there was laughter, there was a lot of conviviality, more than anything we felt comfortable accompanying each other.

This also evidences how the project has strengthened empowerment and cohesion between the women in the group, by creating spaces where they freely interact amongst themselves.

## 8.5 Preparation of Tostadas with Different Flavours

The participants in this group have innovated and modified their recipes to include extra ingredients that allow them to have different flavoured corn tostadas. 'We were not used to flavoured tostadas, this time they asked us to make tostadas that have flavour [...] through my classmates I have learned to add flavour to the tostadas'.

As seen in the previous comment, participation in SF and other projects has allowed group members to exchange recipes and incorporate local ingredients into their tostadas that were not traditionally used. This illustrates an aspect of cultural appropriation among the participants, as they make decisions to innovate by adding local elements, such as local ingredients sourced from their milpa. This innovation not only helps to create new recipes for commercialization in local and external markets but also through SF networks. In this way, the group is internalizing these new techniques for making tostadas.

This promotion of tostadas and the incorporation of different local ingredients—such as beans, cacao, and different maize species—also strengthen their market position, giving the group a competitive edge over locally sold tostadas.

## 8.6 Changes in the Techniques of Making Tostadas for Better Transportation

According to the participants' comments, the actions related to strengthening the *baluarte* in the market and its commercialization are linked to cultural appropriation. The participants innovated their traditional corn tostadas through collective decision-making by preparing them thinner. This change was made to prevent the tostadas from breaking and also to facilitate easier transportation. According to one participant:

> [...] packing them in the bag or in some other package becomes complicated, and flat tostadas are less in danger of breaking; They are going to leave San Cristóbal and Slow Food promotes them and the tostadas must be one size and as flat as possible.

Historically, thicker tostadas were more susceptible to breaking during transportation, which often resulted in them arriving at their destination in poor condition. By refining their techniques, the participants have ensured that the tostadas meet market demands while preserving the essence of their traditional craft. These modifications reflect a deliberate adaptation of traditional practices and innovation in order to address logistical challenges.

### *8.6.1 Incorporation of Ecotechnologies in the Preparation of Tostadas*

Another relevant finding in this *baluarte* reported by participants and project managers involved in initiatives related to the bulwark is the incorporation of ecotechnology into the processes of making corn tostadas. They note that SF has supported the manufacture of stoves that improve the working conditions of those involved in this bulwark.

Using participatory action research techniques aimed at improving practices (Zúniga González et al., 2016), the project began with observing the traditional preparation of corn tostadas. This led to efforts to create a prototype stove specifically for the nixtamalization of corn. Through participatory workshops, participants in the bulwark had the opportunity to utilize these stove prototypes, which have significantly improved their working conditions. The new stoves have reduced the time required to prepare corn tostadas, decreased the amount of firewood needed, and minimized exposure to the prolonged smoke from traditional stove fires.

According to one of the project coordinators, ‘women who commercialize [tostadas] spend many more hours cooking than women who only cook for their own consumption, so they use a lot of firewood, breathe a lot of smoke and take a long time too’.

SF’s support for developing these prototypes is important in fostering dignified work for women engaged in tostada production. This support enhances their sense of security by improving their working conditions (ILO, 2020). It creates opportunities for these women to voice their opinions and actively participate in decision-making processes throughout the project’s development.

## 8.7 Business Plan for Corn Tostadas

It is worth highlighting that one of the objectives of this project was to design a business plan for the bulwark. However, the organizations have faced challenges in achieving this objective due to low participant attendance.

During the work meetings, the participants addressed this activity only superficially, often associating it with the marketing campaign. This observation was supported by fieldwork information, as few participants attended the workshop focused on the business plan. One participant stated, 'the business plan was carried out in the last quarter of last year, with little attendance of the participants'.

The workshop facilitator presented an appropriate methodology and had the necessary experience to create a business plan tailored to the group's needs, such as fair pricing and valuing the participants' work. Despite these efforts, the objective has not materialized. Therefore, this area of opportunity is crucial to ensure the continuity of the work group.

## 8.8 Marketing and Product Commercialization

According to the testimonies of the participants, the objective of the participants included actions such as social media management, taking photographs, and creating and disseminating content. The photographs captured the participants' work and the process of making tostadas. Those who attended the workshops had high expectations regarding the results and the impact the advertising campaign would have on the commercialization of their tostadas. However, by the end of the activities, the participants contrasted their expectations with the actual results. One participant noted: '[they told us that] we would have more sales, we would make ourselves known and they would tell us, we want tostadas, but it was not like that'.

Another shared expectation among the group regarding social media was that their work would be recognized by followers, leading to an increase in their follower count after the advertising campaign was implemented. However, they felt this did not materialize. One participant expressed, 'I think that what I expected from social networks like Tostixim was that we would get more followers, more people who would be interested in the page [...]. The results were not what I expected, [it seems we did not get more followers]'.

It is important to note that, according to the participants' perceptions, followers on social media have requested information about prices and shown interest in their products. However, sales have not been realized through these channels. As one participant shared, 'they [followers] have not made orders through social networks, they have asked us for quotations and everything, but that is all. We send them the prices'.

## 8.9 Re-evaluation of Indigenous Identity

The participation of women toasters in work meetings organized by various organizations has helped establish a collective framework that reinforces their shared identity. These meetings have allowed the women to identify themselves both as caretakers of their households and as practitioners of traditional tostada preparation methods, which are deeply rooted in their cultural heritage. This connection significantly contributes to the strengthening of their identity (Bonfil Batalla, 1991). Fieldwork data further emphasized this identity, as participants highlighted their shared experiences and characteristics. For example, one participant stated, 'They [the participants] are also peasants, they work like us, with corn, beans, everything else. We [empathize] knowing that they also suffer like us, and work like us'.

Participants also recognized the importance of open communication to foster a culture of respect and empower the group. One participant, for example, noted '[we are] learning from each other because we also learn from them, and they learn from us; it is about mutually supporting one another'.

The work meetings were held in spaces specifically designed to accommodate the needs of the women toasters. These spaces were equipped with culturally traditional tools essential for their craft, such as stoves and griddles, which are considered integral to their autonomous culture. One participant shared her observations about the atmosphere during these gatherings: 'We were working at Doña Elena's house, most of them said they felt comfortable working like this, because there was dialogue, there was laughter, there was a lot of conviviality, more than anything we felt […] at ease'. These meetings not only provided a practical setting for collaboration but also fostered a sense of community and solidarity among the participants. Such practices contribute to reinforcing the cohesion and empowerment of the women's group, ensuring its continuity and sustainability over time.

## 8.10 Cultural Appropriation

Cultural appropriation emerged as a significant outcome of the work meetings, particularly in the domain of corn tostada production. Among the primary appropriations involved innovations to traditional recipes, which introduced new flavours and variations in size and texture. These modifications were implemented to align with the group's cultural framework, utilizing locally available ingredients integral to their culinary traditions, such as diverse varieties of corn, beans, tomatoes, and cocoa.

Fieldwork revealed additional innovations appropriated by the participants, including the adoption of wood stoves for tostada preparation. This technological shift was positively received, as it not only enhanced the dignity of their work but also addressed health concerns by reducing exposure to smoke during cooking. These practices underscore the process of cultural appropriation within the group, demonstrating how innovations are integrated in ways that respect and reinforce

their cultural identity while ensuring the sustainability of these activities for future generations.

Reciprocity and trust among participants in the training sessions contribute to strengthening their collective identity through the exchange and transmission of knowledge, as well as the re-evaluation of their products. The intergenerational transfer of knowledge and values, along with the significance of the clay house as a space for these activities and collective travels to other parts of the country and even Italy, also fosters social cohesion and empowers the group. In this context, participants emphasize a strong interest in organizing more exchange activities within their communities and beyond. As one participant noted:

> We visited more places, like the homes of colleagues we didn't know before, like Campo Santiago, and we saw the materials our colleagues use to make their tostadas that we don't have.

For the group, these meetings have played a pivotal role in consolidating their identity as a collaborative group. This has positively impacted the group's empowerment and led to establishing their own governing body: the organizing committee. Organizing these meetings has provided a platform for coordinating tasks and activities, as reflected in the following statement:

> Our role is to learn how to conduct and coordinate meetings for a cooperative or a group, and also to acquire knowledge regarding many functions we were previously unaware of [...] and to keep track of activities while supporting colleagues in whatever they may need.

## 8.11 Decision-Making Structures and Cultural Control

Within the framework of the cultural control theory (Bonfil Batalla, 1991), decision-making structures and mechanisms of cultural control are evident in this context. The participants have established an organizational framework that enables them to govern their activities, monitor group processes, and make decisions that prioritize both the group's future and its alignment with their cultural values. Central to this organization is a control body that oversees work meetings and maintains communication with external associations that collaborate with the group.

This structure ensures that the group retains autonomy in its decision-making, free from external conditions imposed by external civil associations. The control body has played a pivotal role in decisions related to adopting new technologies, modifying traditional recipes, and implementing other innovations. These decisions are made after carefully considering the group's cultural elements, emphasizing their well-being and ensuring the continuity of their practices in a culturally appropriate manner.

## 8.12 Conclusion

The production and sale of corn tostadas represents an activity contributing to conserving the local biocultural heritage (Toledo & Barrera-Bassols, 2008) in Chiapas. This is because indigenous people use agroecological practices, including milpa products, sustainable firewood harvesting, and other local resources, combining traditional techniques to prepare corn tostada that results in a high-quality food product. This activity has primarily been carried out by low-income women as a form of self-employment (Díaz Hernández et al., 2015). The interaction between these women and their environment, along with their connections to various groups and collectives, transforms the space, leaving a 'footprint' that consists of symbolically charged symbols and brands (Vidal & Pol, 2005), leading to a sense of appropriation of the land.

As supported by the cultural control theory framework, the interaction resulting from the exchange of traditional knowledge among local actors—who integrate the autonomous culture and SF's actors sharing the technical knowledge—has brought changes and innovations to the traditional food production practices among the participants. The changes in these practices were made through 'face-to-face' interaction, and workshops were conducted collaboratively between both groups, allowing for the appropriation of new techniques while maintaining cultural identity. The practices aimed at achieving standardization demonstrate that interculturality among the participants has facilitated the development of equitable relationships within the group, as well as between academics and representatives from other organizations involved. This was achieved by actively facilitating spaces and processes of exchange, which enabled mutual engagement and promoted dialogue as well as the sharing of traditional knowledge (Walsh, 2005). This dynamic is reflected in the statements made by participant about their activities within the collective.

Moreover, the construction of knowledge through the exchange of traditional practices fosters a decolonial approach to knowledge that is decentralized (Escobar, 2005). This process highlights the prominence of traditional knowledge preserved within families and passed down through generations, yet it remains at risk from modern knowledge systems. Therefore, practicing traditional knowledge within the collective not only helps to preserve these ancestral skills but also reinforces the participants' sense of identity (Santos et al., 2007).

The testimonies given by the participants and people from the associations, together with the literature review, corroborate the idea that participative methods, such as interacting with people from outside the community, have identified specialized traditional knowledge in agroecology. This has led to positive results for food production among indigenous people (Altieri & Nicholls, 2010).

The activities undertaken by the actors involved in this study have played a significant role in fostering a social construct that integrates innovation and creativity, utilizing the group's cultural elements alongside the natural resources available in their surroundings. As a result, forming the women's group has led to social transformation, challenging modern rationality through intercultural diversity and the

exchange of traditional knowledge (Leff, 2011). This transformation is grounded in a horizontal dynamic among the group participants and between external collaborators, as opposed to a more homogeneous conventional top-down approach. This approach has effectively contributed to the empowerment of the women involved in the project and, consequently, to the project's continuity. However, some aspects of the project, such as developing a business plan and using social networks as marketing tools, could further benefit from a more culturally grounded approach. This could improve the participants' perceptions of the SF's efforts to improve their commercialization strategies.

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## References

Altieri, M., & Nicholls, C. (2010). Agroecología: Potenciando la agricultura campesina para revertir el hambre y la inseguridad alimentaria en el mundo. *Revista de Economía Crítica, 10*(2), 62–74.

Badilla, L. (2006). Fundamentos del paradigma cualitativo en la investigación educativa. *Revista de Ciencias del Ejercicio y la Salud, 4*(1), 42–51.

Bogdan, R., & Biklen, S. (2003). *Qualitative research in education: An introduction to theories and methods*. Pearson.

Bonfil Batalla, G. (1991). La teoría del control cultural en el estudio de procesos étnicos. *Estudios sobre las Culturas Contemporáneas, IV*(12), 165–204.

Chia, J. (2009). *Data analysis, interpretation, and reporting*. I-SHOU University.

Creswell, J. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage.

Díaz Hernández, B. M., Ochoa Fernández, M. P. D., Ramos Maza, M. T., & Cancino Córdova, S. A. (2015). *Trabajo, mercado y género: Mujeres chiapanecas productoras de tostadas de maíz.* Universidad de Ciencias y Artes de Chiapas; Centro de Estudios Superiores de México y Centroamérica; El Colegio de la Frontera Sur; Universidad Autónoma de Chiapas.

Dirección de Información Geográfica y Estadística, Subsecretaría de Planeación, & Comité Estatal de Información Estadística y Geográfica de Chiapas. (2023). *Chiapas: Pobreza 2022.* Comité Estatal de Información Estadística y Geográfica de Chiapas.

Escobar, A. (2005). Más allá del tercer mundo: Globalización y diferencia. Instituto Colombiano de Antropología e Historia / Universidad del Cauca.

Hernández-Sampieri, R., Fernández-Collado, C., & Baptista-Lucio, P. (2014). *Metodología de la investigación* (6th ed.). McGraw-Hill.

International Labour Organization (ILO). (2020). *Decent work.* https://www.ilo.org/global/topics/decent-work/lang%2D%2Den/index.htm

Leff, E. (2011). Sustentabilidad y racionalidad ambiental: hacia "otro" programa de sociología ambiental. *Revista Mexicana de Sociología, 73*(1), 5–46. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-25032011000100001&lng=es&tlng=es

Santos, B. de S., Nunes, J. A., & Meneses, M. P. (2007). Opening up the canon of knowledge and recognition of difference. In B. de S. Santos (Ed.), Another knowledge is possible: Beyond northern epistemologies (pp. xix–lxii). Verso.

Toledo, V. M., & Barrera-Bassols, N. (2008). *La memoria biocultural: La importancia ecológica de las sabidurías tradicionales*. Icaria Editorial.

Vidal, T., & Pol, E. (2005). La apropiación del espacio: Una propuesta teórica para comprender la vinculación entre las personas y los lugares. *Anuario de Psicología/The UB Journal of Psychology, 36*(3), 281–298.

Walsh, C. (2005). Interculturalidad, conocimientos y decolonialidad. *Signo y. Pensamiento, XXIV*(46), 39–50. https://www.redalyc.org/articulo.oa?id=86012245004

Zúniga González, C. A., Jarquín Saenz, M. R., Martínez Andrades, E., & Rivas García, J. A. (2016). Investigación acción participativa: Un enfoque de generación del conocimiento. *Revista Iberoamericana de Bioeconomía y Cambio Climático, 2*(1), 218–224. https://doi.org/10.5377/ribcc.v2i1.5696

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# Chapter 9
# Resilient Roots: Reviving Early Modern Levantine Practices for Agroecological Transformation

**Adel Ghandour, Rami Zurayk, Ali Chalak, and Salma Talhouk**

**Abstract** This chapter explores agroecological knowledge from the Levantine early modern period as a source of indigenous knowledge that could be adapted to the modern world. The research primarily uses the work of Abdul Ghani Al Nabulsi as a source. Al Nabulsi is a polymath who lived between the seventeenth and eighteenth centuries and died in Damascus in 1731 and compiled a wealth of agroecological and agricultural practices and knowledge from his lifetime and earlier from ancient and current sources. This study evaluates traditional Levantine farming methods and their potential applications in modern agroecological practices through historical analysis and scientific research. Indigenous knowledge from the early modern Levant is compared to modern agricultural practices and insights from Africa and Latin America to demonstrate the resilience, adaptability, sustainability, and wealth of these traditional practices. The research employs an interdisciplinary approach to analyse Al Nabulsi's book, involving a critical examination of its content, comparison with recent scholarly works, and a detailed review of the historical context. The findings suggest that traditional agricultural practices promote sustainable and efficient agroecological practices that tackle the challenges of

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contemporary cultivation. Furthermore, integrating these traditional methods with modern agroecological principles can improve food security, reduce environmental impact, enhance ecosystem health, and promote sustainable agricultural practices. This approach highlights the importance of preserving cultural heritage and using indigenous knowledge to inform modern agroecological practices. The study's findings can aid in developing sustainable agricultural policies and enhance local farming practices, preserving cultural heritage, and supporting community development programmes.

**Keywords** Agroecological knowledge · Levantine early modern agriculture · Contemporary agroecological principles · Indigenous knowledge · Cultural heritage preservation

## 9.1 Introduction: The Resilient Knowledge of the Land

From the sun-drenched plains to the fertile valleys of the Levant,[1] agriculture has long been more than a source of sustenance—it is a cultural inheritance, etched into the soil by generations of cultivators. Once central to agrarian civilizations—whose landscapes shaped the rhythms of food production—now relies heavily on global supply chains. Today, the Levant imports nearly 80% of its agricultural needs, marking a sharp departure from its historic self-sufficiency (Baldos et al., 2022). Severed from the ecological knowledge that once ensured abundance, these lands—once home to warriors, poets, and philosophers—show signs of decline, strained by the extractive pressures of industrial agriculture.

Yet traces of another path remain. Abdul Ghani Al Nabulsi, an eighteenth-century Levantine scholar and agricultural observer, compiled *Ilm el-Milaha fi 'Ilm el-Filaha (Ilm)*, a treatise that presents a philosophy of agroecology rooted in cultural heritage and ecological wisdom. His work reflects centuries of localized knowledge and community governance, presenting a worldview in which land was entrusted, not owned—a shared responsibility upheld through seasonal rituals, collective labour, and spiritual traditions.

These practices originated during the Islamic Green Revolution (eighth to thirteenth centuries), a period of agronomic innovation that transformed landscapes from Al-Andalus to the Levant. Scholars documented advanced irrigation systems; introduced crops like rice, sugarcane, cotton, and citrus; and improved crop rotation and soil enrichment techniques (Zaimeche, 2001). These innovations supported Islamic urban centres and Mediterranean trade, laying a foundation for lasting agrarian knowledge.

[1] The Levant, or *al Mashriq* in Arabic, refers generally to the Arab countries bordering the Eastern Mediterranean. These include principally Syria, Lebanon, Palestine, and Jordan. They are part of the historical Fertile Crescent and are one of the cradles of settled farming.

The Levant was an active contributor to this transformation. Under the Umayyads and Abbasids, arboriculture flourished as tax policies incentivized the cultivation of fruit-bearing trees, reinforcing both food security and ecological diversity (Watson, 1983). Incentives—including tax reductions and exemptions—spurred orchard development in accordance with Islamic stewardship principles, particularly *ihya' al-mawat* (reviving unused land), which framed agriculture as both a spiritual obligation and an economic imperative.

In this context, agroecology in the Levant appeared as both practice and governance. Al Nabulsi's treatise depicts a world where wells were dug communally, planting followed celestial cycles, and soil care was guided by intergenerational wisdom. Agriculture was adaptable, participatory, and deeply woven into the social fabric.

As global food systems grapple with climate volatility and deepening social and economic inequality, these historical models gain renewed relevance. Agroecology—now increasingly advanced as an alternative to monoculture and external dependency (Moeller & Ahmed, 2024)—draws on deep roots in Levantine traditions.

This chapter places Al Nabulsi's work within the modern food sovereignty discourse, presenting a model of local agricultural independence that counters corporate dominance. The principles of self-determination, ecological resilience, and responding to local conditions align with agroecological frameworks promoted by the HLPE and FAO (FAO, 2018; HLPE, 2019).

Recovering these insights is not about nostalgia but about restoration. If the Levant once led in agricultural innovation, its legacy is not lost; it remains dormant, ready to inspire new routes to sustainable, community-driven, food systems.

## 9.2 Historical Context: The Agroecological Legacy of the Levant

The Levant, long celebrated for its agricultural richness, sustained an agrarian legacy that balanced productivity with ecological care. By the seventeenth and eighteenth centuries, under Ottoman rule, farming stayed rooted in ancient techniques refined over generations. Communal governance structured land and water use, while spiritual beliefs imbued the landscape with cultural meaning. The empire's decentralized administration—shaped by geographic, ethnic, and religious diversity—allowed local communities to preserve their agricultural traditions, blending inherited agronomic knowledge with Islamic environmental ethics (Yetişgin, 2008). This continuity upheld ecological stability and reinforced the socio-economic fabric of rural life.

With the rise of modernity, however, this equilibrium began to erode. Industrial pressures and centralized governance disrupted traditional systems of stewardship, leaving behind fragments of a once-resilient agroecological model documented in *Ilm*.

### 9.2.1 Agroecology of the Levant

The Levant appears in historical narratives as a cradle of early civilization, where geography, ecology, and agriculture come together to create a resilient agroecosystem. Spanning across present-day Lebanon, Syria, Jordan, Palestine, Israel, and parts of southern Turkey, its diverse topography—including coastal plains, rugged mountains, and fertile valleys—shaped both settlement patterns and farming methods (Suriano, 2018). The Anti-Lebanon Mountains, Beqaa Valley, and the Jordan Rift Valley served as critical lifelines for irrigation, enabling communities to thrive through strategic water management and soil conservation (Doumet-Serhal, 2014). Ecologically, the Levant is characterized by its Mediterranean climate, where olive and citrus orchards thrive along the coast, terraced farming supports mountain communities, and grains dominate the fertile Beqaa Valley (van Zeist & Bottema, 1991). These landscapes showcase a long history of agroecological harmony.

The region's early shift from foraging to farming around 9000 BCE marks one of humanity's first moves towards settled agriculture, establishing the basis for permanent communities and the domestication of wheat, barley, and legumes (Munro & Grosman, 2018; Weiss et al., 2006). This early agrarian system prioritized local adaptation and ecological resilience, much like contemporary concepts of sustainable agriculture. The Islamic Golden Age (eighth to thirteenth century) catalysed further innovation, heralding what scholars now call the Islamic Green Revolution. Advanced irrigation techniques such as qanats, cisterns, and terrace farming not only expanded arable lands but also optimized water use in arid zones, illustrating a deep understanding of ecological stewardship (Doumet-Serhal, 2014). These methods reflected an agroecological approach long before the term existed, integrating crop diversity, water conservation, and soil regeneration to sustain both productivity and environmental health.

Under Ottoman rule (sixteenth to nineteenth century), the Levant saw a formalization of its agricultural economy through the timar system which facilitated large-scale cereal production, olive cultivation, and viticulture. Ottoman agricultural policies promoted land reclamation and improved market access, helping to stabilize food systems through public granaries and cooperative village networks (Faroqhi, 1984). This community-focused approach to agriculture reinforced local food sovereignty, much like modern concepts of cooperative farming and local food networks.

### 9.2.2 Al Nabulsi's Life and Intellectual Contributions

Born in 1641 in Damascus, Abdul Ghani Al Nabulsi lived through a time of political and economic transformation in the Ottoman Empire. A scholar, jurist, and Sufi mystic, his intellectual pursuits included theology, poetry, and agriculture. His thoughts on cultivation resulted in *Ilm*, a pivotal eighteenth-century agricultural

treatise of 222 pages. In the introduction, al-Nabulsi describes the work as a concise adaptation of a sixteenth-century agricultural text *Jāmi‘ farā’id al-malāḥah fī jawāmi‘ fawā’id al-filāḥah* by Radi al-Din al-Gazzi al-‘Amiri (d. 1529).The book covers ten chapters, reflecting his detailed observations of farming practices gathered during his travels across the Levant and his role as a judge and polymath. The text offers comprehensive guidance on seasonal farming methods, similar to Ibn Al-Awam's agricultural calendar.

*Ilm* is a work that transcends the scope of a typical farming manual.[2] Instead of introducing novel techniques, Al Nabulsi combined generations of agricultural knowledge, mixing empirical observation, Islamic environmental ethics, and traditional ecological wisdom into a cohesive, interdisciplinary treatise. As a judge and land administrator, he was well-versed in the agrarian realities of the Levant. His accounts of land tenure, water governance, such as the quote: ‘Know that the irrigation channels in which water flows are dug in the highest place so that it is directed over the entire land when irrigating’ (p. 12), and cultivation practices, like ‘to loosen the earth so that the roots can breathe with the entry of air, to cook the sea of the sun so that it becomes hot and gentle, to turn the interior of the earth over to its exterior, to hold the moisture and water inside it so that the summer is cooled and it becomes moist, and to cut the grass from the earth so that it does not take away the goodness of the earth's food and crowd out the trees’(p. 9) and ‘It is better to plant the high, dry, weak places after harvest, and to plant the wet places at the end of the season, and to plant the hot countries in the fall’ (p. 20), show a nuanced understanding of how ecological sustainability was upheld through community-based governance. The treatise offers a rare and detailed portrait of the socio-ecological systems that sustained early modern Levantine agriculture—preserving a knowledge system rooted in both environmental adaptation and cultural continuity.

### *9.2.3 The Interdisciplinary Nature of* Ilm el-Milaha fi 'Ilm el-Filaha

Al Nabulsi's *Ilm* stands at the crossroads of agronomy, Islamic environmental ethics, and local governance. It combines indigenous agricultural knowledge with the Islamic principle of *khilafah* (stewardship), framing cultivation as a moral responsibility aligned with ecological rhythms. The treatise details traditional agricultural practices such as crop rotation and soil enrichment—illustrated in the quote: ‘If not, then take the pumpkin and the vine leaves, dry them and crush them all, and mix them with fresh water in leather container, then sprinkle the land after light plowing, and throw’ (p. 8), and intercropping as mentioned in *Ilm*: ‘If three or four roots of brown grass are planted next to the vineyard, it will repel flying insects and flies’ (p. 59). These methods form the foundation of what is now called agroecology. The

[2] https://hdl.loc.gov/loc.wdl/wdl.16763

text also covers water management, with irrigation advice such as: 'And know that the canals through which the water flows should be dug at the highest point so that it may dominate all the land during irrigation' (p. 12) and pest control techniques like: 'As for the worms of manure, black and golden ash, and the like, it kills them.... Take the black ash of the baths in which garbage is burned and mix it with sand and salt in an amount of one-sixth and mix it with soil taken from the surface of the earth and put that around the roots after leaving them exposed to the air weekly' (p. 65). These solutions are drawn from empirical observation and ecological awareness.

Beyond its technical contributions, the text shows a governance system rooted in cultural norms and spiritual beliefs. According to the treaties, land use, resource distribution, and labour were organized through customary frameworks reinforced by religious ethics and mystical symbolism. These informal structures ensured fair access to natural resources and sustainable soil management. Together, they created a decentralized model of natural resource governance—an early form of food sovereignty based on community independence and ecological stewardship.

## 9.3 Themes Explored in *Ilm el-Milaha fi 'Ilm el-Filaha*

*Ilm* portrays a world where agriculture was closely attuned to natural cycles, and governance was embedded in the seasonal patterns and inherent agreements of farming communities. Through its emphasis on ecological knowledge, social organization, and the transmission of practices across generations, the treatise reveals a system in which sustainability was a continuous practice. Extracting themes from *Ilm* followed a structured and methodical approach, embedded within a broader qualitative and analytical methodology designed to evaluate the traditional agricultural practices documented by Abdul Ghani Al Nabulsi in the context of contemporary agroecological principles established by the FAO (2018) and HLPE (2019). This approach consisted of the following phases.

### *9.3.1 Ecological Knowledge*

#### 9.3.1.1 Traditional Agronomic Techniques

In *Ilm*, Abdul Ghani Al Nabulsi offers a holistic vision of the Levantine agroecosystem, emphasizing the interdependence of soil, crops, and the community. He emphasizes the importance of maintaining soil fertility, enhancing crop resilience, and sustaining ecological balance. His observations closely match modern agroecological science, which sees soil as a living system where air, water, minerals, and microorganisms interact in dynamic equilibrium—crucial for sustainable agriculture (FAO, 2023).

The traditional farming systems prioritized biodiversity and local adaptation, mitigating environmental degradation while supporting long-term productivity. Traditional agriculture techniques described in Al Nabulsi's treatise are now widely recognized for improving nutrient cycling, strengthening soil structure, and boosting resilience to pests and disease. Unlike the extractive approach of industrial monocultures, Al Nabulsi's model offers a sustainable framework rooted in ecological care and community-based knowledge—one that resonates deeply amid today's ecological crises.

Many of the agronomic practices he documented align with what are now called sustainable or agroecological methods. Among them are the following:

- ***Companion planting and polyculture***

Early modern Levantine agriculture relied on polyculture to increase productivity through the synergistic interactions of different plant species, as one quote from the book states: 'The pomegranate and the myrtle are brothers, and if they are planted together, their fruit is abundant. The apple, the pear, and the citron are familiar with each other, and their fruit is abundant, and each benefits the other' (p. 55). This approach, now central to agroecological theory, promotes biodiversity, enhances soil health, and reduces dependence on chemical inputs by encouraging natural pest control and efficient nutrient cycling. Traditional systems, such as companion planting, significantly influence soil microbial communities, enriching soil enzyme activity and boosting overall soil health (Li et al., 2024). These time-honoured techniques demonstrate a deep understanding of ecological balance and align with modern agroecological principles that emphasize biodiversity and resilience within agricultural landscapes.

Al Nabulsi recorded deliberate crop pairings designed to optimize growth. Aromatic herbs such as mint and basil were planted alongside vegetables to act as natural insect repellents and lessen dependence on synthetic pesticides. Modern science supports these finding: mint attracts *Nesidiocoris tenuis*, a predator of crop pests (Zhang et al., 2020), while basil attracts *Ceraeochrysa cubana*, a key agent in biological control (Hernández et al., 2017). Used as borders or intercrops, basil attract lacewings that suppress soft-bodied pests (aphids, whiteflies, mealybugs, psyllids), strengthening control in diversified systems (Batista et al., 2017).

Vines grown beneath olive trees benefit from dappled shade and improved soil moisture. The intercropping of vineyards and olive groves exemplifies ecological symbiosis. Research shows this pairing improves grape must quality—raising sugar and acid levels—while moderating soil temperature and conserving moisture, thereby supporting vine health (Rallo et al., 2021).

These examples discussed in the book relied on collective labour and shared ecological knowledge, embodying principles of food sovereignty. Just as early farmers protected control over land and practice, today's smallholders continue to resist agribusiness pressures, advocating for localized autonomy and agroecological resilience (Ahmed, 2024).

- ***Innovative propagation methods: the art of seed conservation***

Seed propagation was both a practical necessity and a pillar of ecological resilience. Each harvest reflected accumulated local knowledge, with farmers choosing seeds that had withstood drought, adapted to changing soils, and thrived in variable climates, as Al Nabulsi mentioned: 'When the basil seeds are full, complete and dry, the seeds are stored in perforated clay containers filled with filthy soil and protected from the cold and sun' (p. 109). This method helped preserve genetic diversity attuned to the region's microclimates. Contemporary research affirms its importance: seeds change over planting cycles, improving their genetic traits to match local conditions. Studies on landraces—traditional varieties grown over generations—show they are capable of developing adaptive traits that help them survive in both arid and flood-prone areas (Wuest & Schlegel, 2023).

Al Nabulsi documented various propagation techniques, including grafting, seed saving, and cuttings. His descriptions of grafting lemon, as well as fig trees, document practices shown to improve fruit quality and extend orchard longevity; For instance, 'grafting pears onto apple', 'jujube onto apple', (p. 53) are among the many observations in the book that document grafting practices aimed at improving yield as well as modifying fruit form and flavour. Modern horticulture continues to value grafting for accelerating production, reducing replanting needs, and conserving heritage cultivars (Hartmann et al., 2011; 2018; Kumar et al., 2023a).

The treatise also outlines seed fermentation and drying methods to improve germination—low-input strategies that supported crop renewal. Today, seed saving is seen as essential for climate resilience and food security. Fermenting tomato seeds, for example, removes germination inhibitors and enhances sprouting (Chivasa & Musundire, 2009), while careful drying preserves viability during storage by controlling moisture levels.

These techniques were passed down through oral traditions and communal rituals, anchoring them in a broader intergenerational knowledge system. They stand as a testament to the ingenuity of farmer-led innovation and the enduring value of localized ecological wisdom.

#### 9.3.1.2 Climate Adaptation and Resource Governance

The Levant—shaped by its rolling valleys and arid plateaus—has long been governed by seasonal tempos and climatic variability. Periodic droughts could destroy crops, threatening food security for entire communities. But agriculture in the region was a form of adaptation. Farmers built a responsive relationship with the land, changing their practices based on shifts in rainfall, temperature, and seasons. An example is illustrated in the following quote from the book: 'On the thirteenth of it, the Jabha star begins, and its days are twenty-eight and a quarter day, the number of one of the three known blessed stars. The Arabs said that when the Jabha star is full, it is full. The land is prepared for planting rain-fed flax. In it, the cold breaks and warmth emerges, as grass, and the land takes on its scent and bees' hatch'

(p. 134). Instead of rigid systems, they developed flexible methods tailored to environmental changes—an adaptability essential for survival.

As Rosen (2007) observes, agriculture in the Middle East has, for over 12,000 years, adapted to the Mediterranean cycle of cool, wet winters and hot, dry summers. Levantine farming systems were designed to absorb fluctuations, not oppose them. This legacy of resilience is captured in *Ilm*, where Al Nabulsi documents the practical strategies and collective wisdom farmers employed to navigate ecological uncertainty.

- ***Seasonal adjustments in agriculture***

Rather than relying on fixed calendars, Al Nabulsi documented an agricultural timing that was closely attuned to the observable rhythms of the sky and seasons. His approach emphasized the importance of adjusting farming practices to natural cycles, modifying inputs and activities based on climatic changes and lunar phases. For instance, he noted: 'Manure is used less for vegetables in the summer and in hot land. As for cold lands with moderate temperature, its use is moderate and is increased in the winter and in cold lands' (p. 11). This practice reflects an awareness of how temperature and soil conditions influence nutrient absorption and plant growth. During cooler months, manure application was intensified to enhance soil fertility, while in hotter periods, its use was reduced to prevent soil stress.

Water management followed a similar seasonal pattern. Al Nabulsi explained the strategic use of 'blue water' during summer and 'green water' in the rainy months, carefully avoiding their simultaneous application to optimize soil moisture and prevent saturation. This approach kept the soil productive and well-nourished throughout the year by utilizing water based on the season. Farmers also practiced seasonal flooding in arid zones as a natural substitute for compost, enriching the soil with nutrients carried by water as a method that is both sustainable and resource-efficient.

Tree cultivation was also coordinated with environmental conditions. Newly planted trees received daily watering to develop strong root systems, while mature trees were irrigated less frequently during winter dormancy. Techniques like slow-release watering through clay jars ensured steady hydration, adjusted for seasonal rainfall and summer heat. Soil preparation was similarly scheduled, with deeper pits dug a year in advance to stabilize soil and improve water retention, creating better conditions for root development.

Lunar phases guided planting and harvesting cycles, a practice that Al Nabulsi highlighted for its impact on crop productivity. He remarked: 'Sowing during the waxing of the moon shows growth in crops, the beginning of the months and the waxing of the moon and the fruits increase. And in the basil, legumes, gourds, cucumbers, squash, watermelons, and eggplants, and no crops ever bear fruit during the waning of the moon and that decreases in the thinning of its fruit and its branches extend' (p. 12). This alignment with lunar cycles influenced not only the timing of planting but also pruning, harvesting, and soil preparation, suggesting that observable celestial rhythms played a critical role in optimizing plant health and yield—an approach often dismissed by industrial agriculture but increasingly revisited for its ecological and agronomic benefits. Emerging research suggests that aligning

farming activities with lunar cycles can positively affect plant development and yield, offering scientific support for these traditional methods (Sivasankar & Thimmaiah, 2021).

These practices extended to propagation and soil care, where inputs such as manure, plant debris, and ashes were applied during specific seasons to protect soil quality and enhance fertility. Grafting and pruning followed seasonal rhythms, while companion planting and windbreaks were strategically placed to shield crops from harsh seasonal winds. Farmers adjusted watering schedules based on tree maturity and environmental conditions, ensuring water reached the roots during critical times. For drought-sensitive plants, irrigation was increased in late summer and early fall to prevent moisture loss. Al Nabulsi's observations reflect a model of agriculture that synchronized with natural cycles, emphasizing seasonal timing to boost soil health, crop yield, and ecological balance—a testament to the adaptability of traditional Levantine farming systems. Seasonal responsiveness also served as a form of governance, where management was attuned to land's rhythms and driven by shared ecological responsibility.

#### 9.3.1.3 A Sustainability Philosophy

The Levantine farmers engaged in a responsive dialogue with the land, interpreting its signals through soil texture, moisture levels, and seasonal winds. This attentiveness led to a system of environmental sustainability, often overlooked in contemporary discourse but becoming increasingly crucial amidst today's ecological crises.

In *Ilm*, Al Nabulsi offers an agricultural philosophy that transcends yield-oriented paradigms. His treatise described an agricultural model where sustainability was built in. Soil and water were managed communally using local knowledge, without relying on industrial inputs. Core practices included soil regeneration, organic amendments, and cyclical resource use—ideas that align with modern agroecological principles. Starting with preparing the soil bed for tree planting, the book illustrates the process with the following guidance: 'The hole is deepened for air and food. The best way to dig olive tree holes is to make them wider and deeper, and they are dug a year before planting' (p. 9), ensuring tit meets the needs of the specific species planted: 'The average depth of the hole should not be less than an arm and a half... If the large tree is heavy, it should be deepened and left in place' (p. 22). This foundational step is followed by the application of organic matter for open-field crops, exemplified by the practice of enriching the soil: 'Know that cultivating the land with manure and straw improves the land, especially with beans and barley' (p. 9). These methods reflect core principles of soil regeneration and cyclical resource use: 'This land is also suitable for use: the dregs of olive oil taken from pressing olives, which do not contain salt or anything else. It is sprinkled on it while it is not turned over, then it is turned over, then the sprinkling is repeated, then cow manure is added a lot, then it is left, then it is turned over with small plows, not deep, then barley, fenugreek, chickpeas, squash, chard, and marshmallow are planted, and palm trees are planted in it scattered' (p. 8).

Water management also plays a crucial role in soil treatment and regeneration, as emphasized in several parts of *Ilm*. One example notes: 'And the land that is dominated by bitterness, all its plants that grow perish. The treatment for it is to bring fresh water to it in the second half of April, not before it, but rather at the beginning of May, and to plant it often. If it is planted throughout the summer until September, it is good, but not after it' (p. 8). These practices underscore a deep understanding of sustainable natural resource management, ensuring the continuity of cultivation and the preservation of natural wealth through effective and cyclical use of inputs, harmonizing community practices with environmental sustainability.

Contemporary research affirms the relevance of Al Nabulsi's approach. Techniques described have been shown to enhance soil health, support biodiversity, and ensure long-term productivity (Altieri, 2018). Based on empirical observation and adapted to local environmental conditions, these practices offer viable, ecologically sound alternatives to industrial agriculture (Kumar et al., 2023a, 2023b).

- ***Soil regeneration and organic inputs***

Long before the advent of mechanized agriculture, fertility was a reciprocal relationship between the farmer and the land, sustained through inherited practices. *Ilm* describes a world where decomposed manure, plant residues, and crop rotation were rituals of regeneration. The use of natural cultivation residues to cure diseases and regenerate soil quality is mentioned in many quotes in the book, such as: 'Worms occur in palm trees…. Take the wild cucumber and its leaves, crush them, mix them well with water, and sprinkle them on the vines and other things…. Or feed the orchards roots with cow dung mixed with fine soil for 3 days, and the ashes of fig and grape wood cure worms' (p. 57). The use of organic matter—through livestock integration, composting, and fallowing—sustained soil health and supported long-term productivity. In contrast to the extractive logic of industrial agriculture, these practices fostered resilience across seasons and generations.

Organic fertilization was guided by communal norms and lived experience. As modern agriculture struggles with the environmental impacts of chemical reliance, these traditional methods are being reconsidered as ways to promote ecological renewal.

Contemporary research confirms their effectiveness. Organic amendments enhance soil structure, increase microbial activity, and improve fertility over time (Reganold & Wachter, 2016). Similarly, crop rotation, extensively discussed in Al Nabulsi's work as an effective method for maintaining soil quality and achieving high yields—once considered outdated—is now recognized for its capacity to prevent nutrient depletion and sustain agroecosystem balance (Giller et al., 2021).

- ***Reduction of external inputs through cooperative ecological management***

Farms operated as closed-loop systems, sustained by their own outputs during the documented period in *Ilm*. Fertility came from the cyclical logic of the land, nothing was wasted, and all inputs were locally generated. The notion of importing fertility would have seemed not only impractical but also a break from the ecological rhythms that directed cultivation.

This disruption was later described by Karl Marx as the 'metabolic rift', based on insights from agricultural chemist Justus von Liebig. Liebig observed that industrial agriculture disrupts the nutrient cycle—drawing nutrients from the soil to feed cities without returning them (Liebig, 1855). Marx (1976) and Foster (1999) expanded this analysis, identifying soil depletion as a symbol of capitalism's wider disconnect of society from nature.

Contemporary agriculture aims to repair this rift by reintegrating farming into ecological and cultural systems fractured by industrialization (Foster, 2000). Its most radical expressions aim not just to reform food systems but to restore the metabolic balance between humans and the land.

In the early modern Levant, land use reflected this ethos. Fields were not overworked; pastures were allowed to regenerate, as documented in the following: 'He leaves the animals to graze it, preventing its corruption and making the land grow' (p. 132) and 'He leaves the animals to graze in it, which fertilizes the land and increases its fertility' (p. 74). Grazing cycles followed seasonal rhythms, giving the earth time to recover. These practices were supported by communal governance, where resource decisions were made through shared consensus.

Recent research confirms the importance of such cooperative models. Berkes (2018) and Tschopp et al. (2024) highlight that sustainable governance, based on cultural diversity and collective responsibility, is vital for preserving ecological balance.

These systems embodied a living philosophy: land, water, and sustenance were considered a sacred trust. Governance arose from necessity, belief, and mutual care, not from bureaucracy.

### *9.3.2 Social Networks and Governance*

In the early modern period, the social frameworks supported agroecological resilience, ensuring food remained a common good rather than a market commodity. *Ilm* offers a rich account of these systems. The use of a talisman reflects the role of social and cultural norms in governance, where enhancing field fertility and optimizing productivity were prioritized. The text highlights implications related to gender in some passages and race in others, closely tied to the cultural and religious beliefs of the community. For example, Al Nabulsi mentioned: 'Another talisman is that if a virgin slave girl whose time has come for marriage takes a naked rooster with its hair spread out and walks around the crops with it, then he will be safe from pests and the weeds will be destroyed immediately' (p. 122). Plants have a perceiving soul; this belief originated from Islamic and cultural beliefs, which emphasize that plants possess an alive soul and reflect the community's complete comprehension of nature as a relationship between living organisms and humans. This statement is reflected in the quote: 'As farmers, breeders and wise men agreed, the plant has a perceptive soul, and so it is done with the one that bears fruit one year and does not bear fruit another' (p. 76). By incorporating spiritual beliefs into agricultural

methods, these communities established informal yet effective systems of governance and social organization. This natural system of governance ensured that agricultural practices were environmentally sustainable and aligned with cultural and religious principles. Even though the practices illustrated cannot be supported scientifically, their application conserved a sustainable agricultural system through implicit governance of natural resources.

This model depended on reciprocity, mutual aid, and communal responsibility. In these decentralized networks, the core principles of food sovereignty—local control, ecological stewardship, and social equity—were integral to daily life.

#### 9.3.2.1 Community Collaboration: Cooperative Land Management and Resource Sharing

Levantine agricultural communities engaged in the collective maintenance of irrigation system and the excavation of communal wells to ensure equitable access to water and arable land, particularly in water-scarce regions. Well-digging was a communal effort, carried out through coordinated labour contributions to secure water availability. This practice is illustrated in historical accounts mentioned in *Ilm*, such as: 'Ten or more men stand at the top of the well, holding pots filled with cold water, and then they apply the aforementioned process' (p. 12), which underscores the organized and participatory nature of such activities. These practices reflect a form of localized governance in communal organization and voluntary labour. This aligns with Van der Ploeg's (2020) interpretation of agrarian traditions, wherein governance structures emerged through socially embedded practices of mutual responsibility and resource stewardship.

This ethos extended to land tenure. In the Levant, land ownership was divided between private individuals (*mulk*) and the Sultan (*miri*), who controlled most agricultural land. Agricultural land use was split into tenanted and feudal lands. Tenanted lands were leased through bidding, while feudal lands were subdivided into private, *za'amet*, and *timar*. This feudal system was commissioned in exchange for military support to the Ottoman army (Singer, 1994). Peasants held tenancy rights (tasarruf), cultivating the land and paying taxes, while tax collectors and beneficiaries managed revenue collection. Customary agreements structured harvest divisions, enabling smallholders and tenant farmers to retain access to food and resources. In contrast to contemporary systems marked by privatization, enclosure, and corporate control, early modern Levantine communities prioritized collective well-being over profit. Modern agroecological research affirms the value of such approaches: community-based land governance supports more equitable and sustainable food systems (Altieri & Nicholls, 2020), while cooperative practices like shared irrigation and terrace-building improve yields and bolster resilience against drought and erosion (Gliessman, 2018).

These early models of collective accountability are still instructive. They embodied principles now central to food sovereignty. As contemporary agroecology seeks to reclaim this legacy, the Levantine experience documented in *Ilm* reminds us that

sustainability is a long-standing synergy between people and the natural resources—essential to building just and resilient agricultural futures.

#### 9.3.2.2 Implicit Governance and Food Sovereignty Link

In Abdul Ghani Al Nabulsi's *Ilm*, governance is embedded in everyday agrarian life. Unlike modern institutions that centralize authority through formal laws, the early modern Levantine model functioned through implicit governance—a deeply rooted framework shaped by communal norms, inherited knowledge, and spiritual traditions. Braemer et al. (2009) document similar systems in the Central Levant, where collective management of reservoirs, wells, and underground channels reflected long-standing strategies for equitable water distribution.

Agriculture as a negotiated relationship between people and place is presented in the treatise. Land access was mediated by elders, and spiritual practices reinforced cohesion and reciprocity. Likewise, Wellbrock et al. (2012) trace the evolution of water governance in northwestern Arabia and the southern Levant, highlighting the importance of shared stewardship in sustaining agriculture. This model was based on cultural traditions that connected land, labour, and legacy into a cohesive system of resource management.

- ***Food sovereignty and resource management***

The principles behind the food sovereignty movement—which advocates for local control over agriculture—are not new innovations but extensions of long-standing historical practices. They resonate strongly with the early modern Levantine agroecology. In Al Nabulsi's time, as in today's movements, the central struggle was for autonomy: the right to cultivate without subjugation, to sow without restriction, and to harvest without burdening future generations. Just as contemporary food sovereignty supporters oppose the concentration of food systems in corporate and state hands (La Via Campesina, 2007), early Levantine communities organized agriculture around collective access and mutual responsibility. Resource distribution followed the logic of shared needs.

The spirit of food sovereignty has always existed, which is now expressed through the language of policy, environmental justice, and grassroots advocacy. Today, it echoes through new voices and changing landscapes, but its roots remain firmly grounded in the covenant between people, land, and livelihood.

- ***Community-based water management***

Water scarcity, a persistent challenge in the Levant, was historically managed through collective governance. Al Nabulsi documents the communal regulation of wells and irrigation canals, revealing a decentralized system of stewardship that anticipates modern concerns about water equity. Well-digging and access were governed not by formal institutions but by implicit agreements rooted in local customs and social norms. This aligns with Lightfoot's (1997) analysis of qanat systems,

which depended on coordinated labour to build and sustain underground channels that delivered water across arid terrain.

These irrigation systems operated through negotiated agreements that ensured equitable distribution. The scheduling of irrigation, flow control, and use of moisture-conserving techniques demonstrated a sophisticated ecological understanding aligned with environmental variability. Braemer et al. (2009) highlight how water management in the Central Levant, particularly in the Hawran region, was maintained via communal strategies and shared infrastructure. Similarly, Wellbrock et al. (2012) trace the long-lasting presence of these systems from the Neolithic through Antiquity in northwestern Arabia and the southern Levant, underscoring their resilience in resource-scarce contexts.

- ***The preservation and dissemination of agricultural knowledge***

The connection between governance and food sovereignty is evident in how agricultural knowledge was preserved and shared (Ostrom, 1990). This knowledge spread through mentorship, storytelling, and community gatherings—mechanisms that reinforced local autonomy and built resilience against external disruptions. It was passed orally, allowing communities to maintain control over food production and uphold practices grounded in ecological familiarity. Today's food sovereignty movement continues this effort, opposing the privatization of knowledge, corporate seed monopolies, and the marginalization of traditional techniques by standardized industrial models (IPES-Food, 2016).

Al Nabulsi's treatise also reveals the spiritual dimension of agriculture. Talismans, prayers, and celestial observations formed a governance system that respected natural cycles and viewed farming as traditional ecological knowledge, not resource extraction. This blend of mystical and agrarian traditions aligns with contemporary efforts to integrate indigenous knowledge into global food systems—emphasizing ecological harmony, cultural integrity, and sustainability (Wezel et al., 2020).

By examining the implicit governance in early modern Levantine agriculture, we uncover a paradigm that challenges the extractive logic of industrial farming. It is rooted in reciprocity, cultural cohesion, and ecological care. As the food sovereignty movement pushes for systemic transformation (De Schutter, 2011), *Ilm* reminds us that sustainable agriculture has always been about power, autonomy, and the lasting relationship between people and the ecosystem.

In this context, knowledge-sharing served as governance. Their practices emerged not from institutional mandates but from those who worked the land—shaped by adaptation, sustained by resilience, and rooted in the collective memory of generations (Scott, 2009).

## 9.4 Bridging Past and Present

Reclaiming a knowledge system that has endured colonial subjugation, environmental change, and industrial expansion offers lessons that are still highly relevant today. Al Nabulsi's insights into early modern Levantine agriculture, reshaped land sovereignty, reflect principles now echoed by agroecologists seeking alternatives to extractive production models.

Today, agroecologists advocate similar models of farmer-led governance to traditional ecological knowledge, recognizing that sustainable systems must be shaped by those who work the land, not imposed by distant institutions or top-down policies (Rosset & Martínez-Torres, 2012).

Al Nabulsi's treatise presents a historically grounded model that continues to shape contemporary food sovereignty movements. It affirms that solutions to today's agricultural crises may not lie solely on novel technologies but in the revitalization of enduring systems of knowledge and care—systems that were once central to agrarian life in the Levant.

## 9.5 Policy Recommendations: Reviving Participatory Governance in Agroecology

### *9.5.1 Strengthening Local Agricultural Councils and Cooperative Governance*

Modern agroecological policy must revitalize participatory governance structures, ensuring that farmers, not multinational agribusinesses, dictate the policies that shape their land and livelihoods (Anderson et al., 2021). Establishing local agricultural councils, inspired by historical communal decision-making systems, would restore autonomy, allowing communities to manage land use, implement sustainable practices, and determine their own agricultural futures. These councils could handle land tenure disputes, water rights, and seed-sharing initiatives, ensuring food production stays in the hands of those who grow it.

### *9.5.2 Legal Recognition of Indigenous Knowledge in Agroecological Policy*

The techniques documented in *Ilm* align with scientifically validated principles of sustainable agriculture. Yet, despite mounting evidence, contemporary agricultural policy continues to prioritize industrial models, often dismissing traditional ecological knowledge (TEK) as outdated or anecdotal (HLPE, 2019).

Addressing this challenge involves formally recognizing indigenous and traditional agroecological knowledge within legal frameworks. National policies should incorporate TEK practices into strategic plans, offering institutional support, financial incentives, and legal protections to farmers who uphold these systems (Anderson et al., 2021; IPES-Food, 2016). Acknowledging agroecology as a viable alternative is essential for preserving biodiversity, enhancing soil health, and restoring decision-making power to communities connected to the land.

### *9.5.3 Community Engagement: Revitalizing Agroecological Traditions*

Agriculture in the Levant was based on collective stewardship. Seeds carried generational knowledge, elders shared wisdom through practice, and water was managed as a communal resource (Ostrom, 1990). These traditions intertwined farming with community, memory, and ecological reciprocity.

Industrial agriculture has disrupted this heritage. Seeds are now proprietary commodities, traditional knowledge is eroding, and water, once a shared resource, has been privatized and centralized (De Schutter, 2011). The challenge today is not only to resist these changes but also to restore the systems that have sustained agricultural resilience for centuries (HLPE, 2019).

Reviving seed sovereignty, intergenerational knowledge, and community-based water governance strengthens farming communities' autonomy and reaffirms their bond with the land. These practices safeguard agriculture as a shared inheritance, not a dependency on external systems (Altieri, 2018). Reclaiming them is a commitment to ecological balance, social equity, and lasting food sovereignty.

### *9.5.4 Re-establishing Seed Sovereignty Through Local Seed Banks*

In Al Nabulsi's time, seeds served vessels of memory—carefully selected, preserved, and exchanged to sustain life across generations. Farmers grew them for resilience, fostering genetic diversity that safeguarded crops from drought, pests, and seasonal changes.

Today, that legacy faces threats. Corporate control has turned seeds into proprietary commodities, restricting farmers' ability to plant, save, and replant their varieties (IPES-Food, 2016). Hybrid and genetically modified seeds, designed for market efficiency rather than ecological adaptation, have disrupted traditional conservation practices, creating dependency on multinational suppliers (De Schutter, 2011).

Reclaiming this heritage involves revitalizing local seed banks—community-run repositories where farmers can preserve, exchange, and adapt native varieties. Supported by cooperatives and research institutions, these living archives restore biodiversity to the hands of growers, reinforcing food sovereignty (Van der Ploeg, 2020). In doing so, they protect agricultural autonomy and ensure the continuity of knowledge and resilience rooted in the land itself.

### *9.5.5 Encouraging Knowledge Transmission Through Intergenerational Learning*

In *Ilm*, knowledge extended beyond the written word. It was passed down through spoken language, observation, and woven into the daily rhythms of agrarian life. Elders guided the young by seasons and shared labour, passing down skills through practice rather than formal instruction. Land management was learned through experience, based on ecological interdependence, cultural continuity, and collective responsibility.

Reviving this model requires incorporating intergenerational learning into modern agricultural systems. Elder farmers, as custodians of traditional knowledge, should participate in training programmes, schools, and community workshops to ensure their insights endure amid mechanization and standardization (IPES-Food, 2016). Institutionalizing these exchanges promotes not only ecological literacy but also the social cohesion and local wisdom necessary for long-term agroecological resilience.

### *9.5.6 Reintegrating Water Management as a Shared Resource*

In the Levant, water was once the lifeblood of communities—sustained by collective responsibility and deep-rooted customs. Springs, qanats, and irrigation canals were communal trusts, not just infrastructure, maintained through shared labour and governed by unwritten agreements that ensured local autonomy. Over time, industrial agriculture and state policies have reshaped these systems, replacing community-based stewardship with agribusiness expansion (Trottier, 2019). Traditional water rights, once rooted in necessity and cultural inheritance, have been redefined by economic logics that centralize control in distant hands.

Water is more than a resource; it is the core of land stewardship and community unity. Restoring equitable access is both an environmental necessity and a political duty. To control water means to control life, and giving this control to communities is crucial for reclaiming agricultural sovereignty. Research on traditional irrigation systems, like Algeria's foggaras, highlights their importance as sustainable models of water governance (Arab Center Washington DC, 2022). In contrast, privatizing

water services has taken away communities' agency, worsened inequality, and undermined public rights (Food & Water Watch, 2015).

In the Levant, communal water governance, once documented in texts like *Ilm*, has been undermined by policies that favour large-scale agribusiness. Reviving these practices and resisting water commodification are essential for restoring ecological balance and advancing social justice in the region.

## 9.6 Conclusion

The Levant once nurtured a rich agroecological tradition—one grounded in biodiversity, community governance, ecological reciprocity, and spiritual responsibility. Through the writings of Abdul Ghani Al Nabulsi, particularly *Ilm*, we see a world where land was cultivated through inherited knowledge, shared stewardship, and a deep attunement to natural rhythms.

This chapter argued that early modern Levantine agriculture embodies the core values and practices of agroecology as articulated today: sustainability, resilience, and food sovereignty. Far from being outdated, these traditions offer practical alternatives to the extractive, centralized models of industrial agriculture.

By drawing from Al Nabulsi's interdisciplinary synthesis of agronomy, ethics, and community governance, we identify a framework capable of informing contemporary agroecological transitions. His treatise serves as both a historical record and a living resource—demonstrating how embedded cultural knowledge systems can address the ecological and social demands of today.

As today's food systems face mounting pressures—from climate change to land degradation to political disenfranchisement—reviving indigenous and place-based knowledge becomes an ecological necessity. The future of sustainable agriculture may well depend on our ability to reclaim what Al Nabulsi's generation never forgot: that land, community, and care are inseparable.

## References

Ahmed, K. (2024, October 3). Africa's small-scale revolution against big agriculture: Five farmers talk greener, better food. *The Guardian*. https://www.theguardian.com/global-development/2024/oct/03/africas-small-scale-revolution-against-big-agriculture-five-farmers-talk-greener-better-food

Altieri, M. A. (2018). *Agroecology: The science of sustainable agriculture* (2nd ed.). CRC Press. https://www.routledge.com/Agroecology-The-Science-of-Sustainable-Agriculture/Altieri/p/book/9780367712345

Altieri, M. A., & Nicholls, C. I. (2020). Agroecology and the reconstruction of a post-COVID-19 agriculture. *The Journal of Peasant Studies, 47*(5), 881–898. https://doi.org/10.1080/03066150.2020.1782891

Anderson, C. R., Pimbert, M. P., Kiss, C., & Zanella, M. A. (2021). *Agroecology now!: Transformations towards more just and sustainable food systems*. Palgrave Macmillan. https://link.springer.com/book/10.1007/978-3-030-61315-0

Arab Center Washington DC. (2022). *Confronting water scarcity in North Africa*. https://arabcenterdc.org/resource/confronting-water-scarcity-in-north-africa/

Baldos, U. L. C., Fuglie, K. O., & Hertel, T. W. (2022). Food security in the Middle East and North Africa: The role of agricultural productivity growth and trade. *Food Policy, 107*, 102218. https://doi.org/10.1016/j.foodpol.2021.102218

Batista, M. C., Fonseca, M. C. M., Teodoro, A. V., Martins, E. F., Pallini, A., & Venzon, M. (2017). Basil (*Ocimum basilicum* L.) attracts and benefits the green lacewing *Ceraeochrysa cubana* Hagen. *Biological Control, 110*, 98–106. https://doi.org/10.1016/j.biocontrol.2017.04.013

Berkes, F. (2018). *Sacred ecology: Traditional ecological knowledge and resource management* (4th ed.). Routledge.

Braemer, F., Échallier, J.-C., & Tabet, C. (2009). Long-term management of water in the Central Levant: The Hawran case (Syria). *World Archaeology, 41*(1), 36–57. https://doi.org/10.1080/00438240802668262

Chivasa, S., & Musundire, R. (2009). Assessing the effects of fermentation time on tomato (*Lycopersicon lycopersicum* Mill.) seed viability. *Journal of Sustainable Development in Africa, 10*(4), 112–119.

De Schutter, O. (2011). *Agroecology and the right to food: Report presented at the 16th session of the UN Human Rights Council*. United Nations Human Rights Council. https://www.srfood.org/en/report-agroecology-and-the-right-to-food

Doumet-Serhal, C. (2014). *The Oxford handbook of the archaeology of the Levant: c. 8000–332 BCE*. Oxford University Press.

Faroqhi, S. (1984). *Towns and townsmen of Ottoman Anatolia: Trade, crafts, and food production in an urban setting, 1520–1650*. Cambridge University Press.

Food and Agriculture Organization of the United Nations (FAO). (2018). *The 10 elements of agroecology: Guiding the transition to sustainable food and agricultural systems*. https://www.fao.org/documents/card/en/c/CA7173EN/

Food and Agriculture Organization of the United Nations (FAO). (2023). *Soil ecosystems and sustainable agriculture: Principles for natural fertility management*. https://www.fao.org/4/y1730e/y1730e09.htm

Food & Water Watch. (2015). *Water privatization: Facts and figures*. https://www.foodandwaterwatch.org/2015/08/02/water-privatization-facts-and-figures/

Foster, J. B. (1999). Marx's theory of metabolic rift: Classical foundations for environmental sociology. *American Journal of Sociology, 105*(2), 366–405. https://doi.org/10.1086/210315

Foster, J. B. (2000). *Marx's ecology: Materialism and nature*. Monthly Review Press.

Giller, K. E., Andersson, J. A., Sumberg, J., & Thompson, J. (2021). Beyond monoculture: Agricultural diversification as a response to food system failures in Africa. *Global Food Security, 28*, 100491. https://doi.org/10.1016/j.gfs.2021.100491

Gliessman, S. R. (2018). *Agroecology: The ecology of sustainable food systems* (3rd ed.). CRC Press. https://doi.org/10.1201/9780429495465

Hartmann, H. T., Kester, D. E., Davies, F. T., & Geneve, R. L. (2011). *Plant propagation: Principles and practices* (8th ed.). Prentice Hall.

Hartmann, H. T., Kester, D. E., Davies, F. T., Geneve, R. L., & Wilson, S. B. (2018). *Hartmann & Kester's plant propagation: Principles and practices* (9th ed.) Pearson.

Hernández, M. M., Rojas, J. C., & Malo, E. A. (2017). Attraction of the green lacewing *Ceraeochrysa cubana* to basil (*Ocimum basilicum*). *Biological Control, 109*, 1–5. https://doi.org/10.1016/j.biocontrol.2017.02.003

High Level Panel of Experts on Food Security and Nutrition (HLPE). (2019). *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition*. Food and Agriculture Organization of the United Nations. https://www.fao.org/3/ca5602en/ca5602en.pdf

International Panel of Experts on Sustainable Food Systems (IPES). (2016). *From uniformity to diversity: A paradigm shift from industrial agriculture to diversified agroecological systems*. https://ipes-food.org/reports

Kumar, R., Sharma, N., & Kumar, S. (2023a). Physiological and molecular responses in citrus under abiotic stress: Role of grafting. *Frontiers in Plant Science, 14*, 10584891. https://doi.org/10.3389/fpls.2023.10584891

Kumar, S., Sharma, N., & Kumar, R. (2023b). Innovative organic fertilizers and cover crops: Perspectives for sustainable agriculture. *Agronomy, 14*(12), 2871. https://doi.org/10.3390/agronomy14122871

La Via Campesina. (2007). *Food sovereignty: A right for all* (Political statement of Nyéléni, the first global forum on food sovereignty). https://viacampesina.org/en/food-sovereignty-a-right-for-all/

Li, Y., Chen, H., Zhang, Q., & Zhao, X. (2024). *Intercropping and agroforestry as examples of agroecological cropping systems: Benefits and sustainability*. Springer. https://link.springer.com

Liebig, J. v. (1855). *Principles of agricultural chemistry: With special reference to the late researches made in England*. Walton and Maberly.

Lightfoot, D. R. (1997). Qanats in the Levant: Hydraulic technology at the periphery of early empires. *Journal of Field Archaeology, 24*(1), 3–20. https://doi.org/10.2307/530660

Marx, K. (1976). *Capital: A critique of political economy* (Vol. 1). Penguin/New Left Review. (Original work published 1867). Retrieved from https://www.marxists.org/archive/marx/works/1867-c1/

Moeller, N., & Ahmed, F. (2024). *Tracking agroecology: A framework for measuring transition and system change*. Agroecology Coalition. https://agroecology-coalition.org/wp-content/uploads/2024/04/Tracking-tool-manual-EN-2024.pdf

Munro, N. D., & Grosman, L. (2018). The forager–farmer transition in the southern Levant (ca. 20,000–8,500 cal. BP). In A. Yasur-Landau, E. H. Cline, & Y. Rowan (Eds.), *The social archaeology of the Levant: From prehistory to the present* (pp. 47–66). Cambridge University Press. https://doi.org/10.1017/9781316661468.005

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press. https://www.cambridge.org/core/books/governing-the-commons/3DFF23A6EB168180B788B17CBEFCB8DC

Rallo, P., Camposeo, S., & Palasciano, M. (2021). Agroforestry of olive and grapevine: Effects on must quality and soil properties. *MOspace Institutional Repository*. https://mospace.umsystem.edu/xmlui/handle/10355/85835

Reganold, J. P., & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. *Nature Plants, 2*(2), 15221. https://doi.org/10.1038/nplants.2015.221

Rosen, A. M. (2007). *Civilizing climate: Social responses to climate change in the ancient Near East*. AltaMira Press.

Rosset, P. M., & Martínez-Torres, M. E. (2012). Rural social movements and agroecology: Context, theory, and process. *Ecology and Society, 17*(3), 17. https://doi.org/10.5751/ES-05000-170317

Scott, J. C. (2009). *The art of not being governed: An anarchist history of upland Southeast Asia*. Yale University Press.

Singer, A. (1994). *Palestinian peasants and Ottoman officials: Rural administration around sixteenth-century Jerusalem*. Cambridge University Press.

Sivasankar, S., & Thimmaiah, S. (2021). The importance of harvesting on the last quarter moon. *International Journal of Biodynamics*. https://www.yerbamateonoiru.com.py/en/the-importance-of-harvesting-on-the-last-quarter-moon/

Suriano, M. J. (2018). *Historical geography of the ancient Levant*. Oxford University Press.

Trottier, J. (2019). Water governance in the Levant: Power, politics, and public participation. *Middle Eastern Studies, 55*(4), 563–581. https://doi.org/10.1080/00263206.2018.1563447

Tschopp, M., Brantschen, M., Gass, T., & Jacobi, J. (2024, October 3–5). Assessing the impact of multiple groups of agroecological practices on moderate and severe food insecurity: Analysis

of household data from the Sufosec alliance [Paper presentation]. Agroecology Science Days 2024, University of Lausanne, Switzerland.
Van der Ploeg, J. D. (2020). The politics of agroecology. *Journal of Peasant Studies, 47*(2), 311–340. https://doi.org/10.1080/03066150.2019.1692024
van Zeist, W., & Bottema, S. (1991). *Holocene vegetation of the southern Levant*. Springer.
Watson, A. M. (1983). *Agricultural innovation in the early Islamic world: The diffusion of crops and farming techniques, 700–1100*. Cambridge University Press.
Weiss, H., Courty, M. A., Wetterstrom, W., Guichard, F., Senior, L., Meadow, R., & Curnow, A. (2006). The origins of agriculture in the Near East. *Current Anthropology, 47*(1), 5–35. https://doi.org/10.1086/498523
Wellbrock, K., Voß, P., & Grottker, M. (2012). The evolution of water management methods in north-western Arabia and the southern Levant from the Neolithic Age through Antiquity. *Schriften der Deutschen Wasserhistorischen Gesellschaft, 20*(1), 29–48.
Wezel, A., Herren, B. G., Kerr, R. B., Barrios, E., Gonçalves, A. L. R., & Sinclair, F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems: A review. *Agronomy for Sustainable Development, 40*, 40. https://doi.org/10.1007/s13593-020-00646-z
Wuest, S. B., & Schlegel, A. J. (2023). Soil, precipitation, and crop productivity in dryland farming. In D. L. Sparks (Ed.), *Advances in agronomy* (Vol. 186, pp. 77–108). Academic Press.
Yetişgin, B. (2008). Ottoman administrative practices and societal structures. *DergiPark*. https://dergipark.org.tr/tr/download/article-file/114064
Zaimeche, S. (2001). The advent of experimental chemistry. *Muslim Heritage*. https://muslimheritage.com/the-advent-of-experimental-chemistry/
Zhang, S., Zhang, Y., Ma, K., & Liu, T. (2020). Volatiles from mint attract beneficial predator *Nesidiocoris tenuis*. *Insects, 11*(2), 132. https://doi.org/10.3390/insects11020132

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# Chapter 10
# Climate-Smart Agriculture and Agroecological Perspectives for Sustainable Agriculture

**Md. Rezaul Karim**

**Abstract** Climate-Smart Agriculture (CSA) and Agroecology (AE) have gained significant attention from policymakers, researchers, and development practitioners as leading frameworks for achieving sustainable agriculture. This chapter critically examines the similarities and dissimilarities between CSA and AE, focusing on their theoretical foundations and implementation strategies. The concept CSA, first introduced by the Food and Agriculture Organization (FAO), is centred on three core objectives: sustainably increasing agricultural productivity, enhancing resilience to climate change, and reducing greenhouse gas emissions. Agroecology, in contrast, is defined as the integrative study of the ecology of entire food systems, emphasizing ecological, economic, and social dimensions. Both CSA and AE emphasize the importance of site-specific practices tailored to local contexts. While CSA incorporates certain agroecological practices, critics argue that it does not explicitly reject industrial farming inputs or patented technologies, which can limit the sustainability and local autonomy. In addition, CSA places greater focus on institutional support, intersectoral coordination, and public-private financing mechanisms to scale up innovations. Agroecology, by contrast, draws from traditional knowledge systems and community-based practices rooted in long-standing ecological and socio-cultural values. This chapter provides a nuanced understanding of how CSA can be shaped through an agroecological lens to contribute to more resilient and sustainable agricultural systems. This highlights the inevitable need for both CSA and AE to pursue their objectives in a coordinated manner, contributing collectively to the fight against current and future climate change challenges in the pursuit of sustainable agriculture. Furthermore, this chapter emphasizes the importance of basic as well as applied research on both CSA and AE approaches to support the development of long-term policies that integrate economic, ecological, and social considerations across diverse climatic conditions and regions for the sustainable food system.

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## 10.1 Introduction

According to the United Nations (UN), global policymakers are currently facing two major challenges: increasing crop productivity to ensure there is enough food for the world's growing population and managing natural resources more efficiently without causing ecological imbalances while combating climate change. Considering the first, the world population is projected to reach approximately 10 billion by 2050. Furthermore, current projections indicate that food production will need to increase by 70% to feed the future global population. Addressing this challenge will require sustainable technological innovations to increase and maintain a stable food production system (Totin et al., 2018). Therefore, firstly crop productivity needs to be increased for making enough food available to feed the growing world population, and secondly, natural resources need to be managed more efficiently without causing ecological imbalance.

Climate change poses one of the greatest challenges to agricultural productivity across different regions of the world. Increasing trends in temperature, heightened vulnerability to extreme weather events, and greater seasonal fluctuations are recognized as major threats to global agriculture (Rodino et al., 2022). Variations in weather and climate—such as temperature, precipitation, relative humidity, evaporation, and evapotranspiration—have affected the spatial and temporal distribution of water resources, leading to devastating disasters including floods, droughts, riverbank erosion, and salinity intrusion (Sarker et al., 2011). Different regions worldwide experience frequent natural disasters due to their geographical location and global climate fluctuations. However, approximately 41–50% of the world's cultivable land faces drought conditions each year (Stocker et al., 2013). Future climate change scenarios predict further adverse impacts, particularly on cereal crop production in Southeast Asia. According to the IPCC (2007), rice production could decline by 8% and wheat by 32% by 2050 due to water scarcity, potentially exacerbating food insecurity in the region.

While agriculture is profoundly affected by climate change, conventional farming systems also contribute significantly to greenhouse gas (GHG) emissions through ruminant livestock, fertilizer and pesticide use, and indirect emissions from land-use changes (Rodino et al., 2022). Conventional agriculture heavily relies on external inputs, such as inorganic fertilizers to boost productivity and synthetic pesticides for pest control. The excessive use of these inputs not only pollutes the environment but also poses various health risks to consumers (Rattanasuteerakul & Thapa, 2012). Chemical herbicides, pesticides, and fertilizers contaminate surrounding ecosystems, and the overuse of inorganic fertilizers leads to land degradation, one of the most critical threats to sustainable agricultural production (Niggli et al., 2009).

According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2014), agriculture, forestry, and other land-use systems account for about a quarter of anthropogenic GHG emissions (Smith et al., 2008).

In addition, when both upstream and downstream processes in the agricultural system are included, global food systems contribute 19–29% of global GHG emissions (Vermeulen, Campbell, and Ingram, 2012). By 2030, it is projected that GHG mitigation from agriculture could range between 4500 and 6000 tonnes of $CO_2$ emissions/year, primarily through increased soil carbon sequestration and other mitigation strategies (Branca et al., 2013; Smith et al., 2008). Given this upward trend, agricultural innovations and production systems will need to undergo significant transformation to ensure adequate food supply for the growing population amid the threats posed by climate change (Totin et al., 2018). Therefore, making agriculture more resilient to climate change and ensuring food security for a growing global population are key considerations for agricultural scientists, researchers, and policymakers. At present, new technological innovations and resilient farming system are demanded that could be able to replace conventional farming system leading to sustainable crop production.

In the past decade, Climate-Smart Agriculture (CSA) has gained prominence as a solution to various challenges in the agriculture sector. Its goals include increasing agricultural productivity and income, promoting adaptation to climate change, and supporting GHG mitigation (Long et al., 2016). Many experts now view climate-smart agriculture as a key response to sustainably increase production to meet the needs of a growing population while addressing the impacts of climate change (Totin et al., 2018). CSA can assist land-use systems that facilitate adaptation-mitigation linkage at all levels and thereby plays crucial role in mitigating the effects of climate change on agricultural production (Rodino et al., 2022).

Similarly, the concept of agroecology (AE) was coined at the beginning of the twentieth century. The AE is defined as the 'integrative study of the ecology of whole food systems, encompassing environmental, economic and social dimensions, or more simply the ecology of food systems' (Rodino et al., 2022). The agroecological approach views farm systems as the fundamental units of analysis, wherein mineral cycling, energy flows, biological processes, and socioeconomic relationships are examined as integrated components of a holistic system (Altieri, 1995). Agroecology in the form conservation farming has been composed of traditional knowledge and practices that function without modern external inputs (Niggli et al., 2009).

The concept of sustainable agriculture is based on a holistic approach to managing farm resources, with a primary focus on maintaining soil fertility and crop productivity over the long term (Karim, 2020; Ikerd, 1993). This is achieved by incorporating farming strategies and technologies that are economically viable, environmentally safe, and socially acceptable. Some scholars define sustainable agriculture as the 'ability of agricultural systems to maintain crop productivity over the long term' (Ikerd, 1993) or 'the adaptive capacity of agriculture to adapt to future changes' (Gafsi et al., 2006). The sustainability of any practice can vary both spatially and temporally. Factors such as technology, agricultural system, or individual farmers can influence its sustainability. At the community or farm level, criteria for measuring sustainability can usually be clearly identified and agreed upon. However, assessing sustainability at higher levels, such as regions or countries, can prove challenging. In general, the sustainability of agriculture is contingent upon its

long-term viability, which includes economic sustainability, environmental safety, and social equity (Lichtfouse et al., 2009).

However, in the context of above circumstances linked to sustainable agriculture, it is very logical, and there is significant scope to shape the climate-smart agriculture and agroecological perspectives in a lens of sustainable agriculture. While CSA and AE are rapidly expanding, the important question is to achieve comprehensive understanding on the similarities or dissimilarities between climate-smart agriculture and agroecology in a sustainable manner. Therefore, the aim of this chapter is to systematically review, explore, and understand the similarities and dissimilarities between CSA and AE and to shape them from the perspective of sustainable agriculture (crop yield and food security; ecological soundness based on climate change adaptation and mitigation; and social concerns). The rest of the chapter is organized as follows. First, it presents the historical and conceptual background of both climate-smart agriculture and agroecology followed by their types and elements. Next, it includes the discussion portion consisting of the similarities and/or dissimilarities of CSA and AE. Finally, it draws the conclusions of the two concepts' overlapping, controversy, and synergy effects.

## 10.2 History and Concept of Climate-Smart Agriculture (CSA)

The global climate policy framework was first introduced between 1991 and 1996. A significant outcome of the Rio Conventions was the establishment of the United Nations Framework Convention on Climate Change (UNFCCC), which entered into force in 1994. The Convention focuses on preventing dangerous human interference with the climate system while ensuring food production is not threatened. It was assumed that developed countries would bear much of the responsibility for both causing and reducing GHG emissions. However, their responses could also include assisting developing countries in funding their mitigation efforts (Lipper & Zilberman, 2018).

The Kyoto Protocol, a global agreement, emerged during the development of climate change policy between 1997 and 2001. The protocol focused on comprehensive targets for reducing GHG emissions. One key measure to achieve this reduction is related to agricultural practices, specifically through soil carbon sequestration. Several opportunities for soil carbon sequestration have been identified through improved soil and forestry management practices (McCarl & Schneider, 2001). Furthermore, the Kyoto Protocol laid the groundwork for international cooperation and established many principles of climate policy (Lipper & Zilberman, 2018). Between 2002 and 2007, there was a shift towards creating many bilateral and multilateral agreements. This period was characterized by different countries and alliances leading different climate change strategies. While the European Union (EU) continued to push for the expansion of the Kyoto Protocol, the United States prioritized multilateral agreements that emphasized technological solutions for

reducing GHG emissions through research and development (R&D) collaboration (Tan, 2010).

Climate policy has undergone significant changes since the financial crisis of 2008. The UNFCCC held its Conference of the Parties (COP) 15 in Copenhagen in 2009, aiming to negotiate a global climate treaty to reduce GHG emissions. Although COP 15 failed to reach a comprehensive global climate agreement, it resulted in a deal for developing countries to set emission reduction targets. In 2015, during the COP 21 in Paris, the Paris Agreement was established, marking a global commitment to address climate issues through a combined approach that included mitigation and adaptation strategies. The COP meeting emphasized the urgent need to develop adaptation strategies to protect vulnerable countries (Cooper, 2016).

Subsequently, the concept of climate-smart agriculture was introduced in the FAO report titled 'Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies', presented at a climate change workshop in Barcelona, Spain. The FAO defines climate-smart agriculture as 'agriculture that sustainably increases food productivity and resilience (adaptation), reduces/removes greenhouse gas emissions (mitigation), and enhances the achievement of national food security and development goals' (FAO, 2010).

The climate-smart agriculture initiative highlights the potential of linking emerging sources of climate finance to support the transition towards sustainable agriculture (FAO, 2011). Climate-smart agriculture aims to enhance agricultural production and climate resilience sustainably. It primarily considers achieving food security and development goals amid changing climate conditions and increasing food demand (Lipper et al., 2014; Totin et al., 2018). In 2013, the FAO identified three pillars of climate-smart agriculture: (a) sustainably increasing food productivity and incomes, (b) adapting to and building resilience to climate change, and (c) mitigating or reducing greenhouse gas emissions wherever possible (FAO, 2013). Therefore, climate-smart agriculture aims to achieve three different 'pillars', often referred to as 'tri-wins' (FAO, 2015).

Climate-smart agriculture researchers adopt different perspectives and sustainable goals, including eliminating poverty, ensuring food and nutrition security, and fostering global partnerships (Lipper et al., 2014; Tanti et al., 2022). The potential of CSA to support both adaptation and mitigation strategies is increasingly recognized in the context of seeking joint poverty reduction, food security, environmental responsiveness, and multiple benefits (FAO, 2016). Climate-Smart Agriculture (CSA) is a key component of the European Union's Common Agricultural Policy (CAP). The CAP encourages and supports farmers in adopting CSA practices, such as climate-resilient crop varieties and other sustainable farming techniques, to enhance the resilience of food production against climate change. Additionally, the CAP provides financial assistance to help farmers adopt CSA technologies and invest in the development of related infrastructure and innovations (Rodino et al., 2022). This emphasizes the importance of CSA in a way that connects farmers and policymaker of different the potential regions and in turn influences food production process.

The concept of climate-smart agriculture has garnered significant attention and debate in both national and global policy arenas. The Hague Conference established two parallel global processes focused on policy and science related to climate-smart agriculture. The policy process followed two conferences, which took place in Hanoi, Vietnam, in 2012 and in Johannesburg, South Africa, in 2014. The science process began with a conference in Wageningen in 2011, followed by another conference at the University of California in 2013. On 24 September 2014, the Global Alliance for Climate-Smart Agriculture (GACSA) was launched at the UN Climate Summit (FAO, 2013; Lipper & Zilberman, 2018). The alliance aimed to increase food and nutrition security through climate-smart and resource-efficient practices. Its action plan sought to enable 500 million farmers worldwide to adopt CSA practices by 2030 (Lipper & Zilberman, 2018). Different technologies and practices used as climate-smart agriculture in different contexts are listed in Table 10.1.

**Table 10.1** Types and names of climate-smart agriculture technologies and practices

| Types of CSA | Name of CSA technologies and practices | Sources |
|---|---|---|
| Water smart: Improves water use efficiency | Rainwater harvesting, drip irrigation, water reservoirs, furrow irrigation, mulching, drought-tolerant variety | Abegunde et al. (2020); Khatri-Chhetri et al. (2017); Nyasimi et al. (2017); Ouédraogo et al. (2019); Rosenstock et al. (2016); Sain et al. (2017) |
| Crop smart: Improves crop efficiency | Crop rotation, intercropping, early planting, alley cropping, crop diversification, short-duration crop | Abegunde et al. (2020); Mwongera et al. (2017); Ouédraogo et al. (2019); Rosenstock et al. (2016); Sain et al. (2017) |
| Soil smart: Improves soil use efficiency | Zero tillage, conservation tillage, reduced/minimum tillage, mulching | Abegunde et al. (2020); Khatri-Chhetri et al. (2017); Mwongera et al. (2017); Nyasimi et al. (2017); Rosenstock et al. (2016) |
| Nutrient smart: Improves nutrient use efficiency | Site-specific nutrient management, green manuring, intercropping, composting, organic manure | Abegunde et al. (2020); Ouédraogo et al. (2019); Khatri-Chhretri et al. (2017); Nyasimi et al. (2017); Rosenstock et al. (2016) |
| Carbon smart: Reduces GHG emissions | Agro-forestry, tree planting, multi-strata crop with trees, integrated pest management (IPM), crop diversification | Abegunde et al. (2020); Khatri-Chhetri et al. (2017); Mwongera et al. (2017); Nyasimi et al. (2017); Ouédraogo et al. (2019); Rosenstock et al. (2016) |
| Weather smart: Provides services related to weather advisories | Weather-based agro-forestry, crop insurance, hedge-grows, live fence, windbreaks, weather forecasts | Abegunde et al. (2020); Khatri-Chhetri et al. (2017); Nyasimi et al. (2017); Rosenstock et al. (2016); Sain et al. (2017) |
| Knowledge smart: Use of combination of science and local knowledge | Contingent crop planning, seed or gene bank, insect-disease resistance variety, water stress-tolerant variety | Abegunde et al. (2020); Mwongera et al. (2017); Nyasimi et al. (2017); Sain et al. (2017) |

## 10.3 History and Concept of Agroecology (AE)

The term 'agroecology' has its roots in the early twentieth century. Since then, both its definition and scope have evolved significantly to address agricultural and environmental issues. The term 'agroecology' or 'agroecological concern' was first used by Bensin (1928, 1930, 1935), a Russian agronomist, who proposed the term agroecology to describe the use of ecological methods in research related to commercial crops (Klages, 1942; Bensin, 1930). In the 1950s, the German ecologist/zoologist Tischler (1950, 1953, 1959, 1961) published several articles using the term agroecology. His work focused on the results of agro-ecological research, pest management, and the unresolved issues related to soil biology, plant protection, and the interactions within the insect community in agricultural landscapes, including non-cultivated habitats. Tischler likely authored the first book on agroecology, titled *Agroecology*, where he analysed the different components, such as plants, animals, soils, and climate, and their interactions within an agroecosystem. He also examined the impact of human agricultural system on these components. This approach combined ecology, especially the interactions between biological components at the field level, and agronomy, focusing on integrating agrarian management practices (Tischler, 1965).

A second important book on agroecology was published by the American agronomist Klages (1942). His 1928 article (Klages, 1928) is probably one of the first papers to deal with agroecology without explicitly using the term. He also analysed the ecological, technological, socio-economic, and historical factors that influence agricultural production; his vision is quite different from that of zoologists. The Italian scientist Azzi (1956) defined 'agricultural ecology' as the study of environmental factors such as climate and soil in relation to the development of agricultural plants, including the quantity and quality of yield and seed. However, his analysis did not include entomological aspects. The foundational ideas for his work were established 30 years earlier (Azzi, 1928, 1942). At the end of the 1960s, the French agronomist Hénin (1967) defined agronomy as 'an ecology applied to plant production and agricultural land management'. This definition is not far from Bensin's definition, even though it does not use the term 'agroecology'.

From the 1970s onwards, agroecology continued to be defined as a scientific discipline. By the 1980s, it also began to emerge as both a movement and a set of practices (Gallardo-López et al., 2018). For more historical insights into agroecology as a scientific discipline from the 1970s to the present, one can refer to the works of Hecht (1995), Francis et al. (2003), and Gliessman (2007). These authors note that during the 1960s and 1970s, there was a gradual increase in the application of ecological principles to agriculture, partially in response to the Green Revolution. The Green Revolution led to greater intensification and specialization in farming. During this period, research on traditional farming systems in tropical and subtropical developing countries also had an important influence on this evolution (Janzen, 1973). The concept of organic farming as an alternative model was also discussed in the context of agroecology, highlighted by Rosset and Altieri (1997) and Guthman

(2000). This period was marked by a growing interest in an ecological perspective on agriculture.

The key concept of agroecosystems emerged in the 1970s, proposed by ecologist Odum (Altieri, 1995), who described them as 'domesticated ecosystems', intermediate between natural and engineered ecosystems. Since the early 1980s, agroecology has emerged as a distinct conceptual framework, employing holistic methods to study agroecosystems. Agroecology aims to protect natural resources and provides guidelines for designing and managing sustainable agroecosystems (Altieri, 1989; Gliessman, 1997; Wezel, et al., 2009).

Although agroecology has existed for several decades, different concepts and interpretations have emerged and been discussed in recent years. The term agroecology is not explained by single definition, but it has been regularly (re)defined by many researchers and policymakers from the agricultural socio-ecosystem (Saj et al., 2017). Some interpret agroecology as a science, a social movement, or an agricultural practice (Wezel et al., 2009). Others consider it a transdisciplinary, participatory, and action-oriented approach (Méndez et al., 2013), while some even suggest its adoption as a political action (de Molina & Caporal, 2013).

Conway (1987) further developed the concept of agroecosystem and identified four main characteristics: productivity, stability, sustainability, and equity. In the 1990s, agroecological research approaches began to emerge, leading to the publication of several textbooks and the initiation of academic research and education programmes, particularly in the USA. More recently, higher education programmes in agroecology have been developed in the USA and Europe. Agroecology as a scientific discipline has undergone a significant transformation, moving beyond the field of agroecosystem to a greater focus on the whole food system, which is defined as a global network encompassing food production, distribution, and consumption (Gliessman, 2007). In this perspective, producers and consumers are viewed as actively interconnected parts of the system (Hill, 1985).

However, during the 1960s, 1970s, and 1980s, the term agroecology was not commonly used to explicitly describe a movement. This began in the 1990s, particularly in the USA and Latin America, when people began to use the term to express a new way of looking at agriculture and its relationships with society. Around the same time, a third use of the term emerged, recognizing a set of agricultural practices that aimed to develop a more 'environmentally friendly' or 'sustainable agriculture' (Wezel et al., 2009).

Agroecology today focuses critically on the sustainability of food, feed, and fibre production. It places greater emphasis on the social, economic, and political factors that drive agricultural systems, moving beyond the conditions that have rendered modern industrial and conventional agriculture unsustainable (Wezel et al., 2009). With its strong ecosystem basis, the science of agroecology has become a powerful tool for transforming the food system when combined with an understanding of societal change. Agroecology encompasses much more than just the science of developing improved, safer, and more environmentally friendly food production technologies. It extends beyond being simply a way of farming, such as organic

production. Furthermore, agroecology functions as a social movement grounded in an ecological foundation that promotes justice, relationships, access, resilience, resistance, and sustainability. Ultimately, agroecology aims to connect the ecological and social cultures that helped human society create agriculture in the first place (Gliessman, 2013).

Agroecology supports local farmers in improving their indigenous farming practices as an alternative to the high-input, chemical-intensive agriculture promoted by international corporations (Altieri, 1995; Gliessman, 2007; Wezel et al., 2009). According to Toledo (2011), the three dimensions of agroecology not only makes it an innovative and critical epistemology, strongly linked to other 'hybrid disciplines' such as political ecology, ecological economics, environmental history, and ethnoecology, but also makes agroecology as a productive practice in open opposition to the task of conventional agronomy, generally at the service of large landowners, as well as a social movement linked to the demands of small producers, peasants, and indigenous peoples (Gliessman, 2013). The scientific contribution of agroecology has evolved from the agroecosystems approach, where components and functions of natural ecosystems, including local knowledge and production strategies based on ecological principles (ecological pest management, association of crops and agroforestry systems) are suggested (Argüello, 2015; Gallardo-López et al., 2018). Table 10.2 shows the elements of agroecology.

**Table 10.2** Elements of agroecology

| Elements of agroecology | Definition | Sources |
|---|---|---|
| Scale | Agroecological territorial scales are considered where possible: (a) transition to sustainable agriculture based on agroecological practices; (b) conservation of biodiversity and resources; (c) food systems are embedded in space; and (d) stakeholders support the transition to sustainable food and agricultural systems | Gallardo-López et al. (2018); Wezel et al. (2016) |
| Factors | **Physical-biological**<br>It includes the intervention of flora, macrofauna, mesofauna, microfauna, and microbiota in the mobility of biogeochemical cycles and the mechanical effects of animals and plants | Gallardo-López et al. (2018); García et al. (2012) |
| | **Social, cultural, and economics**<br>These are seen as improving the rural standard of living through food self-sufficiency, satisfaction of local needs, independence, endogenous development, participation, and decision-making, with efficient use of goods and services (production) and equitable distribution, without harming the renewal, reproduction, and distribution of the agro ecosystem | Gallardo-López et al. (2018); Martínez (2004) |
| | **Political**<br>It includes the set of stable power relations (regulations and legal norms) or decisions about the relationships between natural and social processes | De Molina and Caporal (2013); Gallardo-López et al. (2018) |

## 10.4 Discussion: Similarities and Dissimilarities of Climate-Smart Agriculture and Agroecology

The term 'agroecology' is used by different scholars to describe their own, equally diverse, approach to sustainable agricultural development. On the other hand, the climate-smart agriculture (CSA) is not a set of technologies that can be applied universally, but rather an approach that involves different elements embedded in local contexts. Climate-smart agriculture focuses on both on-farm and off-farm activities and involves different types of technologies, policies, institutions, and investments. Like agroecologists, climate-smart agriculture practitioners emphasize the need to think beyond the farm to the wider landscape in which agroecosystems are embedded (Scherr et al., 2012). Many agroecological practices are inherently climate-smart, as they improve nutrient cycling and soil organic matter, enhancing resilience to climate change while promoting carbon sequestration in soils (Rodino et al., 2022).

The three foundational pillars of Climate-Smart Agriculture (CSA) integrate certain agroecological practices with conventional techniques derived from industrial farming systems. While the two approaches share common goals, such as improving sustainability and resilience, CSA often incorporates these within broader technological and market-oriented frameworks. According to the FAO (2010), CSA seeks to enhance agricultural productivity and adaptive capacity, lower greenhouse gas emissions, and contribute to national food security and development objectives-principles that also resonate with agroecological perspectives.

Climate-Smart Agriculture (CSA) focuses on enhancing agricultural productivity in ways that are environmentally sustainable. According to GACSA (2014), this involves improving yields while efficiently managing natural resources, supporting the adaptation of farming systems to climate-related risks, and adopting methods that help lower greenhouse gas emissions. Although CSA and agroecology (AE) share similar goals and practices at farm and landscape levels, CSA tends to operate more prominently within national and international policy frameworks, whereas AE concentrates on the ecological management of crops, livestock, and local food systems. Recognizing their complementary strengths could encourage more integrated and inclusive strategies for agricultural adaptation and sustainability (Saj et al., 2017).

Furthermore, CSA and AE can be viewed as complementary frameworks when analysed across the spatial scales at which they operate. CSA focuses on developing strategies to manage agricultural and food systems under the pressures of climate change. Much of CSA's work is directed at broad governance levels-national, regional, and global—where it engages with social and policy sciences that intersect with international political and economic agendas. Advocates of CSA emphasize the importance of institutional capacity-building and financial mechanisms to disseminate knowledge and facilitate farmers' transitions toward meeting its three core objectives. Effective coordination across sectors—linking climate policy, agricultural development, and food security initiatives—is also seen as critical. In addition, cooperation between public and private financing systems, including those related

to climate adaptation and food security, is considered essential for fostering innovation in agriculture. This multi-scalar and policy-oriented orientation underscores CSA's positioning at the interface between scientific research and policymaking (Lipper et al., 2014).

Although agroecology and climate-smart agriculture share certain goals, they differ significantly in their underlying principles. Climate-smart agriculture (CSA) is primarily defined by its intended outcomes-enhanced productivity, resilience, and reduced greenhouse gas emissions—whereas agroecology (AE) focuses on the methods of production, emphasizing reduced dependency on synthetic fertilizers and pesticides (Rodino et al., 2022). CSA may incorporate a range of technological innovations that sometimes conflict with agroecological values, such as genetically modified crops, patented seeds, and intensive livestock or biofuel systems aimed at increasing productivity. Conversely, agroecology draws upon traditional and ecologically grounded farming systems, prioritizing sustainability over short-term yield gains (Levidow et al., 2014). While AE may not always maximize production in the short term, it can contribute to long-term food security through practices such as crop rotation, cover cropping, and green manuring, which enhance soil fertility and sequester carbon (Newton et al., 2020).

Proponents of Climate-Smart Agriculture (CSA) acknowledge that focusing solely on increasing agricultural productivity, adaptation, and mitigation without integrating environmental and sustainability considerations can result in detrimental and lasting impacts (GACSA, 2014). In contrast, agroecology (AE) has evolved since the 1990s to encompass socio-economic perspectives, addressing food systems more comprehensively by integrating environmental, economic, and social dimensions (Saj et al., 2017).

Climate-smart agriculture also supports financing and investment in market-based approaches to climate change adaptation and mitigation, as well as the funding of 'climate-smart agriculture' projects through carbon offsetting schemes (GACSA, 2014). The commodification of carbon and the creation of private carbon rights in the name of 'green growth' is part of the climate-smart agriculture agenda (Moreno et al., 2015). However, climate-smart agriculture—and especially the corporate version of CSA—represents a continuation of business-as-usual industrial agriculture. Corporate efforts to expand CSA markets for inorganic fertilizers and genetically modified seeds are likely to further destabilize the ecological system and its ability to support contemporary human societies (Steffen et al., 2015). The CSA requires farmers' access to land, seeds, water, credit, and local markets, including the creation of supportive economic policies, financial incentives, market opportunities, and innovative technologies (Pimbert, 2017). While CSA's non-prescriptive approach has drawn criticism from proponents of agroecology for its openness to industrial technologies (Pimbert, 2015), the potential synergies between CSA and AE merit further investigation and integration in sustainable agricultural development (Saj et al., 2017).

Although CSA emphasizes policy development, institutional frameworks, and financial mechanisms, it does not prescribe a fixed set of agricultural practices that qualify as climate smart. Rather, its flexibility lies in the recognition that what

constitutes a 'climate-smart' intervention depends on local ecological and socioeconomic conditions (Lipper et al., 2014). This adaptability can include a broad spectrum of practices—ranging from the use of improved crop varieties and genetically modified organisms to more resource-intensive farming systems—depending on local needs and capacities. On the other hand, the site-specific nature of AE can be advantageous, as it enables the validation and support of traditionally and locally developed farming methods through tailored policy mechanisms. Such approaches have demonstrated benefits at broader scales, including enhanced soil and biomass carbon sequestration, reduced erosion and heat stress, improved soil fertility, and increased food security through diversified production and income sources (Sendzimir et al., 2011).

Climate-Smart Agriculture (CSA) has been criticized for overlooking the ecological principle of *care*, which emphasizes precaution in adopting new technologies such as genetic modification. Within the CSA framework, farmers may become increasingly reliant on genetically engineered seeds, improved animal breeds, and global markets for inputs and sales. However, public acceptance of genetically modified foods remains low, particularly across European nations, due to perceived health risks and ethical concerns. This limited acceptance challenges CSA's compatibility with the broader goals of sustainable agriculture, which require attention to social, environmental, and economic dimensions. In addition, smallholder farmers in developing regions often face barriers such as high costs and limited access to genetically modified seeds. In contrast, agroecology applies ecological principles to agricultural systems (Saj et al., 2017) and promotes fairness by striving for food sovereignty considering present and future generation and reduced dependency on global input suppliers and markets (Pimbert, 2015).

Therefore, both CSA and AE exhibit notable similarities as well as key differences in their contributions to sustainable agriculture. The literature indicates that both frameworks support climate change adaptation by addressing economic and ecological dimensions of sustainability. However, the CSA approach tends to place less emphasis on the social and ethical dimensions that are central to agroecological principles.

## 10.5 Conclusion

The perspectives of both Climate-Smart Agriculture (CSA) and Agroecology (AE) have gained popularity among policymakers and researchers in the recent decades. In this chapter, it has been analysed the contribution of CSA and AE to the sustainable agriculture. It is found that despite the two concepts are varied regarding their historical origins and concept, both aspects are designed to contribute to the adaptation and mitigation of climate change impacts. The concept of climate-smart agriculture was first proposed by the FAO in 2010, aiming to manage agriculture and food systems through three objectives: (a) sustainably increasing agricultural productivity, (b) adapting to and building resilience to climate change, and (c)

developing opportunities to reduce GHG emissions from agriculture. Climate-smart agriculture bridges science and policy to promote climate-smart actions and mobilize funding. However, it can also be discussed in relation to agroecology, defined as 'the integrative study of the ecology of the whole food system, encompassing environmental, economic and social dimensions'.

Climate-smart agriculture and agroecology concepts can be complementary when considering the spatial scales at which they operate. Proponents of climate-smart agriculture have incorporated some agroecological practices and combined them with mainstream industrial agricultural technologies. Critics argue that climate-smart agriculture does not exclude agricultural practices that rely on industrial inputs and seed patents. Intersectoral coordination and public-private financing synergies are also important, including climate and food security financing to support climate-smart agriculture innovation in the agricultural sector. There is no specific climate-smart blueprint; instead, climate-smart agriculture relies on site-specific conditions. Through site-specificity, climate-smart agriculture allows genuine farmers' practices to be recognized and supported by appropriate policies. In contrast, agroecology emphasizes territorial scales and different factors recognizing and incorporating local practices. Thus, there appears to be both complementarity and divergence between climate-smart agriculture and agroecology. Simply put, climate-smart agriculture is a very recent approach that excludes the social concerns of sustainable agriculture, whereas agroecology represents more ancient and traditional aspects for developing a sustainable agricultural system.

It suggests that policymakers, researchers, and development practitioners collaborate through an interdisciplinary platform to address diverse paradigms of sustainable food production. Moreover, substantial investments in both climate adaptation and mitigation will be essential to sustain and enhance agricultural yields in response to the growing global food demand. National and international agencies, including governmental and non-governmental organizations, should provide financial and technological assistance to farmers to facilitate the adoption of CSA and AE practices under varying climatic conditions. Such support should also extend to research and development efforts aimed at advancing innovative CSA and AE technologies that can promote long-term agricultural sustainability. In addition, empirical research is needed to identify specific CSA and AE in different contexts using various indicators and methods to explore their contribution for sustainable agriculture.

## References

Abegunde, V. O., Sibanda, M., & Obi, A. (2020). Determinants of the adoption of climate-smart agricultural practices by small-scale farming households in King Cetshwayo District Municipality, South Africa. *Sustainability, 12*(1), 195.

Altieri, M. A. (1989). Agroecology: A new research and development paradigm for world agriculture. *Agriculture, Ecosystems & Environment, 27*(1–4), 37–46.

Altieri, M. A. (1995). *Agroecology: The science of sustainable agriculture*. Westview Press, 433 p.

Argüello, A. (2015). Agroecology: scientific and technological challenges for agriculture in the 21st century in Latin America. *Agronomía Colombiana, 33*(3), 391–398.
Azzi, G. (1928). *Agricultural Ecology* (in Italian). Tipografia Editrice Torinese, 237 p.
Azzi, G. (1942). *Agricultural ecology* (in Italian). Dante Aleghieri, 204 p.
Azzi, G. (1956). *Agricultural ecology*. Constable, 424 p.
Bensin, B.M. (1928). *Agroecological characteristics description and classification of the local corn varieties chorotypes*.
Bensin, B. M. (1930). Possibilities for international cooperation in agroecological investigations. *International Review of Agriculture. Monthly Bulletin of Agricultural Science and Practice (Rome), 21*, 277–284.
Bensin, B. M. (1935). Agroecological exploration in the Soto la Marina region, Mexico. *Geographical Review*, 25 (2) , 285–297.
Branca, G., Lipper, L., McCarthy, N., & Jolejole, M. C. (2013). Food security, climate change, and sustainable land management. A review. *Agronomy for Sustainable Development, 33*, 635–650.
Conway, G. R. (1987). The properties of agroecosystems. *Agricultural Systems, 24*(2), 95–117.
Cooper, M. (2016). The economic and institutional foundations of the Paris Agreement on Climate Change: The political economy of roadmaps to a sustainable electricity future. Available at: https://ssrn.com/abstract=2722880 or https://doi.org/10.2139/ssrn.2722880
de Molina, M. G., & Caporal, F. R. (2013). Agroecología y political, Cómo conseguir la sustentabilidad? Sobre la necesidad de una agroecología política. *Agroecología, 8*(2), 35–43.
FAO. (2010). *Climate smart agriculture: Policies, practices and financing for food security, adaptation and mitigation*. Food and Agriculture Organization.
FAO. (2011). *Climate change mitigation finance for smallholder agriculture: A guidebook to harvesting soil carbon sequestration benefits*. Food and Agriculture Organization.
FAO. (2013). *Climate smart agriculture sourcebook*. Food and Agriculture Organization.
FAO. (2015). *Food and Agriculture Organization of the United Nations Statistics Division (FAOSTAT)*.
FAO. (2016). *State of food and agriculture report "climate change agriculture and food security"*. FAO.
Francis, C., Lieblein, G., Gliessman, S., Breland, T. A., Creamer, N., Harwood, R., & Poincelot, R. (2003). Agroecology: The ecology of food systems. *Journal of Sustainable Agriculture, 22*(3), 99–118.
GACSA, (2014). *Framework Document.* The Global Alliance for Climate-Smart Agriculture (GACSA) Series Document 1. The FAO, Rome.
Gafsi, M., Legagneux, B., Nguyen, G., & Robin, P. (2006). Towards sustainable farming systems: Effectiveness and deficiency of the French procedure of sustainable agriculture. *Agricultural Systems, 90*(1–3), 226–242.
Gallardo-López, F., Hernández-Chontal, M. A., Cisneros-Saguilán, P., & Linares-Gabriel, A. (2018). Development of the concept of agroecology in Europe: A review. *Sustainability, 10*(4), 1210.
García, Y., Ramírez, W., & Sánchez, S. (2012). Indicadores de la calidad de los suelos: una nueva manera de evaluar este recurso. *Pastos y forrajes, 35*(2), 125–138.
Gliessman, S. (2013). Agroecology: Growing the roots of resistance. *Agroecology and Sustainable Food Systems, 37*(1), 19–31.
Gliessman, S. R. (1997). *Agroecology: Ecological processes in sustainable agriculture*. CRC Press.
Gliessman, S. R. (2007). *Agroecology: The ecology of sustainable food systems*. CRC Press, Taylor & Francis, 384 p.
Guthman, J. (2000). Raising organic: An agro-ecological assessment of grower practices in California. *Agriculture and Human Values, 17*, 257–266.
Hecht, S. B. (1995). The evolution of agroecological thought. In M. A. Altieri (Ed.), *Agroecology: the science of sustainable agriculture* (pp. 1–19). Westview Press, Boulder, CO.
Hénin, S. (1967). *Les acquisitions techniques en production végétale et leurs applications* (pp. 31–44). Économie Rurale, SFER.

Hill, S. B. (1985). Redesigning the food system for sustainability. *Alternatives, 12*, 32–36.

Ikerd, J. E. (1993). The need for a system approach to sustainable agriculture. *Agriculture, Ecosystems & Environment, 46*(1-4), 147–160.

IPCC. (2007). Summary for policymakers. In M.L. Parry, O.F. Canziani, J. P. Palutikot, P. J. van der Linden, & C. E. Hanson (Eds.), *Climate change 2007: Impacts, adaptation and vulnerability*. Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change.

IPCC. (2014). Contribution of Working Group II to the fifth assessment report of the Intergovernmental Panel on Climate Change. In M. L. Parryn, O. F. Canziani, J. P. Palutikot, P. J. van der Linden, & C. E. Hanson (Eds.), *Climate change 2007: Impacts, adaptation and vulnerability*. Cambridge University Press.

Janzen, D. H. (1973). Tropical agroecosystems. *Science, 182*, 1212–1219.

Karim, M. R. (2020). Biochar for promoting sustainable agriculture. In *Zero Hunger* (pp. 123–130). Springer.

Khatri-Chhetri, A., Aggarwal, P. K., Joshi, P. K., & Vyas, A. K. (2017). Farmers' prioritization of climate-smart agriculture (CSA) technologies. *Agricultural Systems, 151*(2017), 184–191.

Klages, K. H. (1928). Crop ecology and ecological crop geography in the agronomic curriculum. *Agronomy Journal, 20*(4), 336–353.

Klages, K. H. W. (1942). *Ecological crop geography* (p. 615). Macmillan.

Levidow, L., Zaccaria, D., Maia, R., Vivas, E., Todorovic, M., & Scardigno, A. (2014). Improving water-efficient irrigation: Prospects and difficulties of innovative practices. *Agricultural Water Management, 146*, 84–94.

Lichtfouse, E., Navarrete, M., Debaeke, P., Souchere, V., Alberola, C., & Menassieu, J. (2009). Agronomy for sustainable agriculture. A review. *Agronomy for Sustainable Agriculture, 29*, 1–6.

Lipper, L., Thornton, P., Campbell, B.M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Mann, W., McCarthy, N., Meybeck, A., Neufeldt, H., Remington, T., Sen, P.T., Sessa, R., Shula, R., Tibu, A., & Torquebiau, E. F. (2014). Climate-smart agriculture for food security. *Nature Climate Change*, 4(12), 1068-1072.

Lipper, L., & Zilberman, D. (2018). *A short history of the evolution of the climate smart agriculture approach and its links to climate change and sustainable agriculture debates*. Climate Smart Agriculture, Natural Resource Management and Policy.

Long, T. B., Blok, V., & Coninx, I. (2016). Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: evidence from the Netherlands, France, Switzerland and Italy. *Journal of Cleaner Production, 112*, 9–21.

Martínez, R. (2004). Fundamentos culturales, sociales y económicos de la agroecología. *Revista de Ciencias Sociales (Cr), 1*(103–104), 93–102.

McCarl, B. A., & Schneider, U. A. (2001). Greenhouse gas mitigation in US agriculture and forestry. *Science, 294*(5551), 2481–2482.

Méndez, V. E., Bacon, C. M., & Cohen, R. (2013). Agroecology as a transdisciplinary, participatory, and action-oriented approach. *Agroecology and Sustainable Food Systems, 37*(1), 3–18.

Moreno, P. I., Denton, G. H., Moreno, H., Lowell, T. V., Putnam, A. E., & Kaplan, M. R. (2015). Radiocarbon chronology of the last glacial maximum and its termination in northwestern Patagonia. *Quaternary Science Reviews, 122*, 233–249.

Mwongera, C., Shikuku, K. M., Twyman, J., Läderach, P., Ampaire, E., Van Asten, P., & Winowiecki, L. A. (2017). Climate smart agriculture rapid appraisal (CSA-RA): A tool for prioritizing context-specific climate smart agriculture technologies. *Agricultural Systems, 151*, 192–203.

Newton, P., Civita, N., Frankel-Goldwater, L., Bartel, K., & Johns, C. (2020). What is regenerative agriculture? A review of scholar and practitioner definitions based on processes and outcomes. *Frontiers in Sustainable Food Systems, 4*, 577723.

Niggli, U., Fliebach, A., Hepperly, P., &Scialabba, N. (2009, April). *Low greenhouse gas agriculture: mitigation and adaptation potential of sustainable farming systems*. FAO, Rev. 2-2009.

Nyasimi, M., Kimeli, P., Sayula, G., Radeny, M., Kinyangi, J., & Mungai, C. (2017). Adoption and dissemination pathways for climate-smart agriculture technologies and practices for climate-resilient livelihoods in Lushoto, Northeast Tanzania. *Climate, 5*(3), 1–22.

Ouédraogo, M., Houessionon, P., Zougmoré, R. B., & Partey, S. T. (2019). Uptake of climate-smart agricultural technologies and practices: Actual and potential adoption rates in the climate-smart village site of Mali. *Sustainability, 11*(17), 4710.

Pimbert, M. (2015). Agroecology as an alternative vision to conventional development and climate-smart agriculture. *Development, 8*(2–3), 286–298.

Pimbert, M. (2017). Perspectives: Agroecology as an alternative vision to climate-smart agriculture. *Farming Matters, 33*(2), 9–13.

Rattanasuteerakul, K., & Thapa, G. B. (2012). Status and financial performance of organic vegetable farming in Northeast Thailand. *Land Use Policy, 29*, 456–463.

Rodino, S., Butu, A., & Ifrim, A. M. (2022). Climate smart agriculture: Concept and perspectives. In *Agrarian economy and rural development-trends and challenges. International symposium* (13th ed., pp. 248–255). The Research Institute for Agricultural Economy and Rural Development (ICEADR).

Rosenstock, T. S., Lamanna, C., Chesterman, S., Bell, P., Arslan, A., Richards, M. B., Rioux, J., Akinleye, A. O., Champalle, C., Cheng, Z., & Corner-Dolloff, C. (2016). *The scientific basis of climate-smart agriculture: A systematic review protocol* (CCAFS Working Paper).

Rosset, P. M., & Altieri, M. A. (1997). Agroecology versus input substitution: A fundamental contradiction of sustainable agriculture. *Society & Natural Resources, 10*(3), 283–295.

Sain, G., Loboguerrero, A. M., Corner-Dolloff, C., Lizarazo, M., Nowak, A., Martínez-Barón, D., & Andrieu, N. (2017). Costs and benefits of climate-smart agriculture: The case of the Dry Corridor in Guatemala. *Agricultural Systems, 151*, 163–173.

Saj, S., Torquebiau, E., Hainzelin, E., Pages, J., & Maraux, F. (2017). The way forward: An agro-ecological perspective for Climate-Smart Agriculture. *Agriculture, Ecosystems & Environment, 250*, 20–24.

Sarker, D. C., Pramanik, B. K., Zerin, A. I., & Ara, I. (2011). Climatic impact assessment: a case study of Teesta barrage irrigation project in Bangladesh. *International Journal of Civil & Environmental Engineering, 11*(1), 99–110.

Scherr, S. J., Shames, S., & Friedman, R. (2012). From climate-smart agriculture to climate-smart landscapes. *Agriculture & Food Security, 1*, 1–15.

Sendzimir, J., Reij, C. P., & Magnuszewski, P. (2011). Rebuilding resilience in the Sahel: regreening in the Maradi and Zinder regions of Niger. *Ecology and society, 16*(3), 1.

Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., McCarl, B., Ogle, S., O'Mara, F., Rice, C., Scholes, B., & Smith, J. (2008). Greenhouse gas mitigation in agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences, 363*(1492), 789–813.

Steffen, W., Katherine, R., Johan, R., Sarah, E. C., Ingo, F., Elene, M. B., Reinette, B., Stephen, R. C., Wim de, V., Cynthia, A. W., Carl, F., Dieter, G., Jens, H., Georgina, M. M., Linn, M. P., Veerabhadran, R., Belinda, R., & Sverker, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science, 347*(6223), 1–10.

Stocker, T. F., Qin, D., Plattner, G. K., Alexander, L. V., Allen, S. K., Bindoff, N. L., Breon, F. -M., Church, J., Cubasch, U., Emori, S., Forster, P., Friedlingstein, P., Gillett, N.., Gregory, J., Hartmann, D., Jansen, E., Kirtman, B., Knutti, R., …, Xie, S. P. (2013). Technical summary. In *Climate change 2013: The physical science basis. Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change* (pp. 33–115). Cambridge University Press.

Tan, X. (2010). Clean technology R&D and innovation in emerging countries—Experience from China. *Energy Policy, 38*(6), 2916–2926.

Tanti, P. C., Jena, P. R., & Aryal, J. P. (2022). Role of institutional factors in climate-smart technology adoption in agriculture: Evidence from an Eastern Indian state. *Environmental Challenges, 7*, 100498.

Tischler, W. (1950). Ergebnisse und Probleme der Agrarökologie, Schrift. Landwirtschaft. *Fakultät Kiel, 3*, 71–82.
Tischler, W. (1953). Neue Ergebnisse agrarökologischer Forschung und ihre Bedeutung für den Pflanzenschutz. *Mitteilungen der Biologischen Zentralanstalt, 75*, 7–11.
Tischler, W. (1959). Stand und Möglichkeiten agrarökologischer Forschung, Naturwissenschaft. *Rundschau, 12*, 291–295.
Tischler, W. (1961). Pflanzenschutz in Nordwestdeutschland aus agrarökologischer Sicht, Schrift. Landwirtschaft. *Fakultät Kiel, 28*, 55–70.
Tischler, W. (1965). *Agrarökologie*. Gustav Fischer, 499 p.
Toledo, V. M. (2011). La agroecología en Latinoamérica: tres revoluciones, una misma transformación. *Agroecología, 6*, 37–46.
Totin, E., Segnon, A. C., Schut, M., Affognon, H., Zougmoré, R. B., Rosenstock, T., & Thornton, P. K. (2018). Institutional perspectives of climate-smart agriculture: A systematic literature review. *Sustainability, 10*(6), 1990.
Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. (2012). Climate change and food systems. *Annual Review of Environment and Resources, 37*, 195–222.
Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., & David, C. (2009). Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development, 29*, 503–515.
Wezel, A., Brives, H., Casagrande, M., Clement, C., Dufour, A., & Vandenbroucke, P. (2016). Agroecology territories: places for sustainable agricultural and food systems and biodiversity conservation. *Agroecology and Sustainable Food Systems, 40*(2), 132–144.

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# Chapter 11
# Emergence of Agroecology in India: Exploring the Science, Policy, and Practice Interface

**Soutrik Basu and Prasoon Kumar Singh**

**Abstract** Agroecology is an alternative farming method that relies on the synergistic effects of agronomic practices, thereby using less external input. Globally, it has been touted as a solution to unsustainable industrial agriculture, which has precipitated the ecological and farming crises. Despite the dominance of industrial agriculture in India, agroecology has emerged as an alternative paradigm for sustainable agriculture. This chapter aims to understand the emergence of agroecology in India by exploring the cases of System of Rice Intensification (SRI) and Zero Budget Natural Farming (ZBNF). Analytically, this research draws on the science-policy-practice interface (SPPI) framework to explore the emergence of SRI and ZBNF. This chapter argues that the emergence of agroecology in India followed diversified pathways with less support from the Indian NARS, primarily through bottom-up initiatives by the state departments of agriculture. However, if agroecology aspires to fulfil its transformative potential, it must significantly engage with the knowledge, policy, and political-economic factors of Indian agrarian systems, which are currently missing.

**Keywords** Agroecology · SRI · ZBNF · SPPI · India

## 11.1 Introduction

The definition of agroecology has been evolving for quite some time (Gliessman, 2018). An agroecological farming system adheres to certain guiding principles, including the enhancement of agronomic practices, maximization of ecological processes, utilization of locally available knowledge and farm inputs, and conservation of natural resources. The system typically leverages a synergistic effect of its guiding principles on crop production (Orozco-Meléndez & Paneque-Gálvez, 2022;

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Tittonell, 2020). However, agroecology is scarcely promoted by governments, multilateral institutions, and private agri-business. Pant (2016) argues that the industrial agri-food regime denigrates agroecology as an unscientific, low-productive and obscurantist enterprise. Yet, agroecology is practiced in 63 countries in 230,000 hectares of land (Schiller et al., 2023). The global reach of agroecology is primarily attributed to the involvement of civil society organizations (CSOs), peasant movements, and non-governmental organizations (NGOs) (Orozco-Meléndez & Paneque-Gálvez, 2022).

Unlike the dominant agri-food regime, which follows a productivity-oriented industrial paradigm,[1] an agroecological system is socially and ecologically resilient and is more sustainable and equitable than the industrial agri-food regime (Holt-Giménez & Altieri, 2013; Orozco-Meléndez and Paneque-Gálvez, 2022). Agroecology's role in transitioning *to agri-food sustainability*, thereby contributing to the achievement of the SDGs, has gained global momentum (Sorensen et al., 2025).[2] The UN's Food and Agriculture Organization (FAO) convened the Second International Symposium on Agroecology in 2018 to initiate a dialogue on scaling up agroecology to support the SDGs (FAO, 2018). Agroecology has been promoted and evaluated as a remedy for the agrarian crisis stemming from the prolonged emphasis on productivity-oriented industrial agriculture (Dorin, 2022; Schiller et al., 2023).

In India, too, agroecology has been presented as an alternative to input-intensive Green Revolution (GR) policies shaped by the productivist paradigm. Adopted from the 1960s onward to rapidly increase food production, GR policies and associated practices have precipitated an agrarian crisis with ecological, economic, and nutritional consequences (Dorin, 2022; Kumar, 2019). In the past two decades, numerous agroecological methods have emerged in India (Ramakumar & Arjun, 2019), among which two variants—the System of Rice Intensification (SRI) and Zero Budget Natural Farming (ZBNF)—have garnered significant interest from policymakers, practitioners, and scientists. Our Scopus research revealed 117 journal articles and reviews on SRI in India between 2004 and 2025, as well as 90 articles and reviews on ZBNF between 2017 and 2025, respectively.[3] These two collectively constitute a significant share of India's agroecological niche. The objective here is to explicate the emergence of agroecology in India by unravelling these two agroecological innovations. To do so, the science-policy-practice interface (SPPI) framework (Tambe et al., 2023) is employed to explore the complex interactions

[1] The dominant agri-food regime, contingent upon an exploitative relationship with natural resources, on the one hand, and making farmers socio-economically vulnerable, on the other, is unsustainable.

[2] In their scoping review, Sorensen et al. (2025) provide a comprehensive overview of existing research that illustrates the diverse contributions of agroecology to several SDGs (goals such as 1, 2, 3, and 4).

[3] Search terms included Zero Budget Natural Farming *or* Zero-Budget Natural Farming; Andhra Pradesh Community Managed Natural Farming; APCNF AND Andhra Pradesh; Natural Farming + India; and System of Rice Intensification AND India.

between knowledge, policy, and practice across the agroecological niche and the incumbent agri-food regime (Geels et al., 2023).[4] The SPPI framework is commensurate, as agroecology encompasses both a scientific field and a social movement, as well as a practice (Sorensen et al., 2025). This chapter argues that the emergence of agroecology in India followed diversified pathways, with inadequate support from the Indian National Agricultural Research System (NARS), mostly through bottom-up initiatives by various state departments of agriculture.[5] However, if agroecology is indeed to play a significant role in transforming Indian agriculture, it must engage substantially with the knowledge, policy, and political economy factors of Indian agriculture.

This chapter is organized as follows. After this introductory section, the analytical framework for SPPI is presented in Sect. 2, followed by two consecutive empirical sections on SRI and ZBNF in Sects. 3 and 4, respectively. Section 5 discusses the findings and concludes the chapter.

## 11.2 Theoretical Framework

The literature that helps us analyze and understand the emergence of agricultural innovation has evolved over time (Klerkx et al., 2012). On the one hand, the technology-transfer paradigm emphasizes a linear relationship between research and society, wherein a standardized technology package is disseminated to farmers' fields through extension agencies, with the expectation of bringing about technological change. The Agricultural Innovation Systems (AIS), on the other hand, conceptualizes technological change as an interactive process of knowledge production and diffusion among inventors, institutions, policymakers, farmers, and other enterprises pertinent to a specific country, sector, and/or technology (Basu et al., 2018). AIS is the most widely used framework for analyzing agricultural innovation (Pigford et al., 2018). However, AIS is inappropriate when understanding the emergence of agroecology (Vanloqueren & Baret, 2009). This is because the configurations within AIS favor the dominant agri-food regime; thus, it either marginalizes alternative innovations or undermines their potential by co-opting them (Holt-Giménez & Altieri, 2013). Since the dominant agri-food regime in India is

[4] Our conceptualization of the agroecological niche and input-intensive regime is drawn from Geels' multi-level perspective (MLP) framework of socio-technical transitions. Geels' conception of a niche refers to a space that experiments with radical innovation and is protected from being undermined by the prevailing regime. A regime, on the other hand, is the dominant socio-technical configuration that has been stabilized over decades and resists change from niche (Geels et al., 2023).

[5] In the federal set up of the Indian governance system, administration of various policy domains is allocated between the union government and the state governments. The governance of agriculture largely lies with the state governments. However, several critical issues pertaining to agriculture such as research, trade, and finance are decided by the union government.

input-intensive industrial agriculture, it is unlikely that the Indian AIS will provide a suitable framework for analysis.

Therefore, this research takes intellectual inspiration from the literature on the science-policy-practice interface (SPPI) to analyze the emergence of agroecology in India. SPPI literature offers a broader understanding of the interrelationships between how conventional science informs policy, how emerging practices intersect with science, and how policymaking navigates the intersection of science and practice. SPPI has three different models: *the linear model*, *the power dynamics model*, and *the stakeholder engagement model*. The *linear model* is akin to the technology-transfer model explained above, which assumes a science-led policy process, often popularized as following technocratic governance ideals. *The power dynamics model* views the science-policy-practice interface as a strategic space where different actors build alliances and strategically utilize science and other forms of knowledge to negotiate outcomes. Scientific knowledge is used here for a political end, contrary to the linear model, where science is supposed to dictate the political end. The *stakeholder engagement model* is a participatory model where science is expected to gradually shape the worldview of various stakeholders, including farmers, policymakers, and other relevant stakeholders. Stakeholder engagement models view science as co-produced through participatory processes, which can help build consensus on contested topics (Cáceres et al., 2016). For our analysis, we have chosen to utilize the power dynamics model due to its suitability in exploring the science, movement, and practice facets of agroecology in India.

The power dynamics model comprises four interconnected components: *discourses and narratives*, *actors and networks*, *politics and interests*, and *policy spaces* (Keeley and Scoones, 2014).[6] Understanding *discourses and narratives* requires exploring the dominant framing of agroecology in terms of science, policy, and practice. It also requires us to identify the narratives surrounding agroecology that are emerging. A narrative is a socially constructed storyline that may or may not have scientifically validated knowledge. We explore several narratives around SRI and ZBNF here. Together, these narratives constitute a discourse. Discourse is a means of reflecting on how specific ideas gain prominence over others and become institutionalized within society (Hajer, 1995).[7] For agroecology in India, this may imply identifying emerging scientific and policy discourses and understanding how they interact with the existing discourse. *Actors and Networks* include the promoters of agroecology, their connections, the alliances formed, and how these alliances have evolved in relation to the spread of agroecology. *Politics and Interest* require an exploration of power dynamics and a contestation of agroecology with the incumbent agri-food regime, particularly with knowledge institutions, such as the

[6] Interestingly, these four components directly correspond to the questions, requiring exploration, mentioned in this Anthology's preface titled "Sustainable Agroecology: Actors, Practices, Experiences and Perception", VS Springer Eds: Bacerril/Martinez/Jha/Tuider/Thiel.

[7] In a Foucauldian sense, discourse is a power system that legitimizes one set of thinking and restricts all other forms (Joutsenvirta, 2009), leading to the creation of certain forms of rationalities within the society (Foucault, 2003).

Indian NARS. Finally, *Policy Spaces* refers to understanding how agroecology is being adopted or not adopted into higher-level policy thinking and policy stipulations (Keeley & Scoones, 2014; Cáceres et al., 2016). What kind of space is opening up for agroecology, and how? The following sections on SRI and ZBNF are organized according to these four components of the *power dynamics model* to explain the emergence of agroecology in the Indian context.

## 11.3 System of Rice Intensification (SRI) in India

Father Henri de Laulannié, a French Jesuit priest in Madagascar, developed SRI in 1983. It consists of practices such as using single seedlings at a young age, wide spacing, alternate wetting and drying (AWD), and aerobic soil management, as well as active aeration through mechanical weeding and the use of organic sources of nutrients (Uphoff, 2003). Promoters of SRI claim that it reportedly utilizes 25–50% less water while simultaneously achieving a 20–40% increase in yield and productivity compared to conventional rice farming (Stoop et al., 2002). Thus, the promoters consider SRI an agroecological and low external-input farming method (Maat & Glover, 2012). According to CIIFAD (2018), SRI has experienced widespread adoption worldwide.[8] Moreover, several leading rice-producing and consuming nations, including China, Vietnam, Indonesia, and Cambodia, have established national research and extension programs to promote SRI. The first experiment on SRI in India took place in Pondicherry in 2000. Subsequently, the southern states, such as the erstwhile Andhra Pradesh and Tamil Nadu, pioneered the implementation of SRI, from where it was disseminated to other regions of India, including Bihar and Tripura (Basu, 2009; Basu & Leeuwis, 2012; Prasad, 2006). Principles of SRI have also been extended to other crops such as wheat (SWI), sugarcane (SSI), and mustard (SMI) (Dhar et al., 2016; Gupta et al., 2018).

### *11.3.1 Discourses and Narratives of SRI in the Indian Context*

The first narrative surrounding the introduction of SRI posits that the resolution to this agrarian crisis can't arise from the same technological paradigm of modifying genetic potential, inundation, and application of synthetic fertilizer that precipitated the crisis in the first place. The resolution lies elsewhere, in some alternative agroecological paradigm, premised on a greater understanding of plant-soil-environment relationships and the resulting synergies, as seen with SRI (Prasad & Sen, 2010). The second narrative that emerged for SRI was its potential. Indian rice productivity, in terms of yield growth, slowed substantially in the 1990s and 2000s after a

[8] https://sri.ciifad.cornell.edu/images/global/SRI_World_Map_2018.png.

rapid increase in the 1980s (Samal, 2013). SRI's promise of a significant increase in yield, compared to conventional rice cultivation, led to its inclusion in the National Food Security Mission (NFSM), a national mission of the Indian government that began in 2007 with the explicit objective of raising rice productivity in the country (Basu, 2009).

The third narrative referred to the water-saving potential of SRI. Rice cultivation, particularly the conventional inundation method, accounts for approximately 70% of the fresh available water in India (Biswas, 2010). Moreover, 50% of rice cultivation in India is situated in rain-fed areas with uncertain and limited water availability, where GR methods have had little success. Thus, the promise of SRI, as a water-efficient method compared to conventional rice cultivation, seemed appealing (Basu, 2009). Besides, the adoption of AWD irrigation over the inundation method has been found to reduce methane emissions in paddy cultivation, a concern expressed in Intergovernmental Panel on Climate Change (IPCC) reports (Suryavanshi et al., 2013). The final narrative centered on the economic appeal of SRI. Since SRI does not require expensive external inputs such as hybrid seeds, synthetic fertilizers, irrigation, and/or pesticides, it reduces cultivation costs and increases yields; thus, it promises economic profitability to resource-poor farmers (Maat & Glover, 2012). These four narratives collectively form the discourse surrounding SRI in India. The discourse presented this scenario: SRI raises profitability by reducing input costs and increasing production, thereby leaving a smaller environmental footprint. Thus, promotion and broad adoption of SRI align closely with several SDGs in the country (Thakur et al., 2022).

### *11.3.2 Actors, Networks, and Institutional Mechanisms of SRI Promotion in India*

An estimate from 2013 suggests that 1.5–3 million farmers had experimented with SRI, covering 1–3 million ha of land in more than 13 states in India. SRI promotion in these sundry states included various *actors*, *networks*, and *diverse institutional mechanisms* (Palanisami et al., 2013; Prasad & Barah, 2013). A variety of *institutional Actors* are involved in promoting SRI in several states. These included the State Department of Agriculture (Bihar, Tripura, and Tamil Nadu), Donor Organizations (Sir Dorabji Tata Trust, Deshpande Foundations, Aga Khan Foundation, etc.), Civil Society Organizations (WASSAN and PRADAN, etc.), Regional Rural Banks such as the National Bank for Agriculture and Rural Development (NABARD[9]), Rural Livelihood Missions (Odisha Livelihood Mission, Bihar Rural Livelihood Promotion Society), International Institutions (World Bank,

[9] NABARD is a union government-owned premier development financial institution with a focus on agriculture and rural development.

World Wide Fund for Nature, etc.), and Private Sector (Basix, Usha Martin, etc.) (Prasad & Barah, 2013).

Moreover, we also observe the involvement of various individual actors, who play the role of *innovation champions* for SRI promotion. Innovation champions are influential persons who can make policy decisions, initiate network building, and mobilize resources to spread innovation (Klerkx et al., 2010). For example, people such as Norman Uphoff from the CIIFAD; Dr. A. Satyanarayan, then Director of Extension, State Agricultural University, former Andhra Pradesh; Dr. Rita Sharma, then Additional Secretary, Ministry of Agriculture and Farmer's Welfare (MoAFW); Prof. Thiyagarajan from the Tamil Nadu Agricultural University (TNAU); and Dr. Baharul Mazumdar, senior agronomist, Department of Agriculture, Tripura, played important role in the promotion of SRI (Basu, 2009; Basu & Leeuwis, 2012).[10]

SRI followed diverse institutional mechanisms for various states. For example, in the northeastern state of Tripura, SRI was promoted in a decentralized manner through the Panchayati Raj institutions (Suchiradipta & Raj, 2015), while Bihar undertook the promotion under the auspices of the Bihar Rural Livelihood Promotion Society (BRLPS), popularly known as *Jeevika*. *Jeevika* employed women-led self-help groups (SHGs) to promote SRI (Singh, 2019). In erstwhile Andhra Pradesh, SRI promotion was achieved by building a heterogeneous support network comprising civil society organizations (CSOs), such as WASSAN, the state agricultural university and its extension centers, and international environmental organizations, including the WWF. The national SRI symposiums took place in Hyderabad in 2006, Tripura in 2007, and Coimbatore in 2008, serving as a national venue to advance the SRI initiative (Basu & Leeuwis, 2012). In all three states (Andhra Pradesh, Tripura, and Tamil Nadu), where the national symposia took place, are also the states that initiated SRI promotion through their respective agricultural departments. It did not originate from the union government, unlike other agricultural innovations, such as the HYVs and GMOs. Therefore, SRI followed a bottom-up process.

### *11.3.3 Politics and Interest Around SRI in India*

The politics surrounding SRI operate at two levels: first, in the realm of knowledge production, and second, at the political-economic level. Resistance from these two realms also impedes SRI's wide adoption. There is tension between the niche agroecological knowledge of SRI, practiced by several non-conventional knowledge actors, and the regime-level knowledge produced by NARS. In the Indian context, this tension has been shaped by the *Rice-War* played at the global level between the International Rice Research Institute (IRRI) and other SRI researchers on the

[10] For a more detailed analysis of innovation champions for SRI and specific role played by these people (see Basu, 2009; Basu & Leeuwis, 2012).

scientific merit of SRI (Dobermann, 2004; Sinclair & Cassman, 2004; Stoop et al., 2002; Mcdonald et al., 2006; Uphoff et al., 2008). The *rice war* negatively impacted Indian NARS to carry out large-scale SRI experimentation (Prasad, 2016). However, some NARS scientists conducted SRI research. Nonetheless, their research highlighted aspects of SRI that fitted well with the objectives of the dominant agri-food regime. Such studies incorporated the simplified narrative of SRI as a superior farming technique (Nirmala et al., 2021). The broader possibilities offered by agroecology were neglected.

Although the promoters consider SRI easily accessible and desirable to resource-poor farmers, given its higher yield and reduced cultivation cost (Maat & Glover, 2012), Taylor and Bhasme (2019), through their empirical study in Telangana, observed wide dis-adoption of SRI by the farmers after a season or two, even after impressive yield. They attributed the dis-adoption to the SRI methodology, which requires time-bound access to resources such as labor, water, and networks that only a handful of wealthy farmers can afford. Resource-poor farmers with low social capital often lack the necessary resources to benefit from SRI. Moreover, SRI reduced the demand for female labor due to the adoption of manual weeders that is reported to be operated mainly by men. In an empirical study on SRI in Andhra Pradesh, Gathorne-Hardy et al. (2016) showed that the demand for female labor in paddy cultivation decreased significantly under SRI compared to conventional rice cultivation.

### *11.3.4 Policy Spaces for SRI in India*

Since SRI was introduced in India through the non-conventional channels, the policy space for its research, extension, and promotion via regular policy networks was restricted. For example, inclusion of SRI in the All India Coordinated Crop Improvement Project (AICRIP) trials or extension through the KVKs was initially unavailable. The World Bank, which had considered SRI not only for its yield potential but also for its ecological benefits, also acknowledged in its report the lack of convergence between SRI and the Indian agrarian knowledge and policy ecosystem. The initial window of opportunity for policy support, in fact, came at the state level. For example, the World Bank promoted SRI as a water-conserving technology in Tamil Nadu in the Irrigated Agriculture Modernization and Water-Bodies Restoration and Management (IAMWARM) project. Similarly, in Bihar, the state government integrated SRI as a component of the livelihood promotion scheme supported by the World Bank (Basu, 2009; Singh, 2019).

An interactive policy dialogue on the upscaling of SRI took place in May 2009 at the state agricultural university campus in Hyderabad, hosted in collaboration with the Directorate of Rice Research (DRR). This policy dialogue included participants from the now-defunct Planning Commission of India, Vice-Chancellors of various agricultural universities, Directors from the NFSM, Chief Secretaries of prominent rice-producing states, and SRI advocates from WWF, ANGRAU, DRR,

and WASSAN.[11] During this discussion, the Planning Commission recommended more precisely delineating the basic criteria for designating something as SRI (Directorate of Rice Research, 2009). Following this policy dialogue, SRI was incorporated into the NFSM (Basu & Leeuwis, 2012). In an article published in *Economic and Political Weekly* in May 2011, the then Deputy Chairman of the former Indian Planning Commission mentioned SRI's inclusion in the upcoming Twelfth Five-Year Plan (2012–17) (Ahluwalia, 2011).

## 11.4 Zero Budget Natural Farming (ZBNF)

The FAO (2021) describes ZBNF as an agroecological farming method that integrates modern and traditional science, resulting in decreased input costs, climate change mitigation, and the creation of sustainable agricultural livelihoods. Subhas Palekar developed ZBNF in the 1980s. ZBNF relies on inherent soil fertility, indigenous seed varieties, and microbial treatments derived from bioresources such as dung and earthworms (Pandey & Cabral, 2025). Specifically, it comprises of four strategies. First, treating the seed with locally available microbes such as cow dung and urine, known as *Bijamrita*; second, enhancing soil inoculant and organic matter, termed as *Jivamrita*; third, cover cropping and mulching, referred to as *Acchandana*; and fourth, soil aeration, called *Whapahasa* (Veluguri et al., 2021).

ZBNF has adopted several nomenclatures, including Andhra Pradesh Community Managed Natural Farming (APCNF) in Andhra Pradesh, Subhas Palekar Natural Farming (SPNF) in Himachal Pradesh, and Natural Farming (NF) or *Bharatiya Prakritik Krishi Paddhati* (BPKP) within the national policy framework, to reflect the subtleties within its practices.[12] Nine states in India implement natural farming, as stated on the National Mission on Natural Farming (NMNF) website.[13] The southern states of Karnataka, Kerala, and Tamil Nadu have seen the adoption of ZBNF through grassroots movements, while Andhra Pradesh, Gujarat, and Himachal Pradesh have policies in place to encourage natural farming. In Andhra Pradesh, approximately one million farmers are engaged in natural farming across 1,011,302 acres, while around 100,000 farmers participate in Karnataka. The Gujarat government claims that 700,000 farmers are practicing natural farming in the state (Prasad et al., 2024; Veluguri et al., 2021; Khadse et al., 2018). The FAO is also interested in promoting ZBNF in certain countries in the Global South.

[11] National Institution for Transforming India (NITI) Aayog replaced the Planning Commission in 2015 as the union government of India's leading policy think tank.

[12] For example, the shift from ZBNF to APCNF happened in 2020 to recognize farmers' role in adapting ZBNF practices with non-ZBNF practices, including the application of vermicompost, NADEP compost, and pre-monsoon dry sowing.

[13] https://naturalfarming.dac.gov.in/Schemes/NFPackages.

### 11.4.1 Discourses and Narratives of ZBNF in the Indian Context

The initial two words of ZBNF—zero and budget—are associated with the most powerful narrative around it. The term "Zero Budget" denotes the reduction of production costs by minimizing external inputs while simultaneously increasing income from diverse sources. This revolves around the *agrarian crisis* narrative in the country, stemming from the persistence of input-intensive industrial agriculture, characterized by escalating input costs and its failure to achieve economies of scale through farm expansion and consolidation (Dorin, 2022). The second narrative emerging with ZBNF is sustainability. Proponents claim that ZBNF meets all three components of sustainability: economic, social, and ecological. Economic sustainability denotes the profitability of ZBNF, whereby farmers can achieve surpluses after deducting all cultivation expenses. Social sustainability signifies that disadvantaged and marginalized populations can embrace and benefit from ZBNF. Environmental sustainability pertains to its positive ecological nature, which seeks to halt and reverse the degradation of natural resources, especially soil. Quantitative research corroborates these narratives, particularly in the context of Andhra Pradesh (Jaacks et al., 2022; Das et al., 2024; CSTEP, 2019). The overarching discourse surrounding ZBNF regarded it as possessing a transformative agenda for transitioning to sustainability in Indian agriculture and alleviating the agricultural crisis, potentially expediting some of the Sustainable Development Goals (Ramdas & Pimbert, 2024).

### 11.4.2 Actors, Networks, and Institutional Mechanisms of ZBNF Promotion in India

Since 2016, several states in India have implemented ZBNF, either as grassroots initiatives, as in Karnataka, Kerala, and Tamil Nadu, or through state-sponsored programs, as in Andhra Pradesh, Himachal Pradesh, and Gujarat. At the union level, the National Institution for Transforming India (NITI) Aayog, India's principal planning institution, is endorsing natural farming. In Andhra Pradesh, the parastatal organization *Rythu Sadhikara Samstha* (RySS) serves as the nodal agency for promoting ZBNF/APCNF. RySS's model includes farmers' organizations and self-help groups (SHGs) in the planning, implementation, and monitoring of ZBNF promotion on the one hand, and the inclusion of champion farmers as community resource persons (CRPs), on the other. RySS also coordinates with other partners such as the NITI Aayog, Azim Premji Philanthropic Initiatives (APPI), state agricultural university (SAU), state rural livelihood mission (SRLM), CSOs, and international donor agencies such as the Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ).

In Karnataka, the promotion of ZBNF is carried out by the peasant organization, the *Karnataka Rajya Raitha Sangha* (KRRS). KRRS is also a member of the international peasant movement organization, La Via Campesina (LVC). LVC has consistently promoted agroecological innovations through farmer organizations to achieve food sovereignty. Although KRRS is an upper-caste peasant organization, it strategically allied with the environmental and Dalit movements to promote ZBNF. KRRS conducted several state-level workshops and utilized farmer-to-farmer knowledge exchange to create collectives that adopted ZBNF. Moreover, KRRS's leadership mobilized the necessary resources to disseminate ZBNF. Apart from the state government in Gujarat, the Agricultural Technology Management Agency (ATMA) and Gujarat Natural Farming Science University (GNFSU) promote ZBNF. Since 2020, a nationwide coalition of civil society organizations, the National Coalition for Natural Farming, has emerged, recognizing Natural Farming as the trajectory and process of transitioning towards a more localized, resilient, and adaptive agroecological farming system.

### *11.4.3 Politics and Interest Around ZBNF in India*

The contestation over ZBNF has two features: first, on its scientific merit, mostly coming from NARS and agricultural economists, and second, on its transformative agenda for sustainability, coming from the agroecology practitioners. In 2019, the National Academy of Agricultural Sciences (NAAS), the country's premier academy of agricultural scientists, opposed the promotion of Zero Budget Natural Farming (ZBNF) due to concerns regarding food insecurity, farmer income, and the lack of scientific proof.[14] Ramakumar and Arjun (2019) make a similar case against the promotion of ZBNF, characterizing the arguments forwarded by its proponents as implausible. They questioned the basic assumptions of ZBNF by noting that Indian soils do not have sufficient nutrients for crops and therefore require external additions. More fundamentally, they argue that proponents have a poor understanding of the process of nutrient absorption in plants. And finally, they point to the lack of any independent scientific study substantiating the claims of ZBNF. The transformative agenda of ZBNF is the other point of contestation, which also exemplifies the global tension "between the reformist and radical versions of agroecology" (Holt-Giménez & Altieri, 2013). Critical appraisals have highlighted the limited articulation of the agrarian crisis in the implementation of ZBNF. As a result, ZBNF appears to be a superficial solution for the problems of Indian agriculture that have been exacerbated by neoliberal policies and the state's retreat. In fact, it has been argued that such policies resemble tokenism and advance cultural nationalism, which might help avoid the reckoning that profiteering, unsustainable, and

[14] https://www.thehindu.com/news/national/govt-should-stop-promoting-zero-budget-natural-farming-pending-proof-scientists/article29386358.ece.

input-intensive agriculture deserves. For achieving transformation, a radical version of agroecology that incorporates diverse aspects of agriculture's political economy, such as those related to land and livestock ownership, wage labor, caste, and gender, must be integrated into policy formulation for agroecology (Abrol, 2023; Ramdas & Pimbert, 2024).

### *11.4.4 Policy Spaces for ZBNF in India*

Gradually, the concept of natural farming has gained policy space in India. The first significant policy support came from the Andhra Pradesh government, which created RySS, a parastatal organization, in 2014. RYSS began administering ZBNF in 2016.[15] The Himachal Pradesh government, in 2018, developed the Prakritik Kheti Khushal Kisan Yojana (PKKKY) to promote natural farming through a dedicated natural farming unit within the state's agricultural department, which incorporated ATMA and engaged NGOs, SAUs, and women's groups.[16] The Gujarat government's organic policy in 2015 led to the adoption of ZBNF, which was implemented through the organic cell and ATMA, in alliance with the SAUs and religious political groups (Prasad et al., 2024). The "major moment of policy space" was created in 2019–2020, when the union government initiated the *Bharatiya Prakritik Krishi Paddhati* (BKPK) program to advance natural farming as part of its existing *Paramparagat Krishi Vikas Yojana* (PKVY) initiative.[17] The NITI Aayog endorsed natural farming despite objections from the NAAS.[18] On November 25, 2024, the union government scaled up its natural farming initiative by announcing the National Mission on Natural Farming (NMNF) with a proposed total budget of ₹ 2481 crore, aimed at expanding natural farming to one crore farmers nationwide by the end of 2026 (MoAFW, 2025).

## 11.5 Discussion and Conclusions

This chapter aimed to understand the emergence of agroecology in India by examining the science, policy, and practice aspects of two prevalent agroecological innovations: SRI and ZBNF. This final section synthesizes the findings from the preceding two sections to conclude the chapter. Initially, we present a comparative analysis of SRI and ZBNF, followed by a broader discussion on agroecology in relation to

[15] https://apcnf.in/ryss/.

[16] https://spnfhp.in/.

[17] https://naturalfarming.dse.gov.in/Initiative/BPKP.

[18] See https://naturalfarming.niti.gov.in for the efforts of NITI Aayog toward promoting Natural Farming.

knowledge, policy, and the political economy. Interestingly, we see in the previous sections that agroecological systems in India, particularly SRI and ZBNF, emerged notwithstanding an antagonistic incumbent agri-food regime[19] deeply embedded in the input-intensive industrial agrarian paradigm (Raina, 2015), an unfavorable policy milieu shaped by technology-centric neoliberal thinking (Kumar, 2019; Patnaik, 2003), and reluctant knowledge institutions, particularly the Indian NARS, not willing to substantively engage with agroecology (Prasad et al., 2024). However, SRI and ZBNF exhibited significant divergence in terms of knowledge-geopolitics, policy adoption, and the sustainability transition of Indian agriculture, as explained below.

The long-standing influence of the IRRI-India knowledge network on Indian rice research and policy rendered the introduction of SRI through unconventional knowledge networks a significant departure in the geopolitics of rice knowledge. In contrast, ZBNF was an indigenous development that also created its own knowledge networks, primarily supported by the state departments of agriculture. The future of agroecology and its role in transforming Indian agriculture will depend on how these types of knowledge networks interact with more conventional knowledge networks, such as NARS and KVKs, to explore collaborative possibilities between diverse knowledge traditions. Such collaborative possibilities will also have implications for the conventional extension system in India, which is mainly based on uniform institutional arrangements and targeted at large-scale irrigated agriculture. Such a system must be reformed to accommodate the knowledge-intensive practices of agroecology, diverse institutional mechanisms, and the challenges of rainfed agriculture. However, seeking such collaborative possibilities would require knowledge dialogues to break down institutional hierarchies and rigidities. It would require reconceptualizing the extension system by shifting the focus from hierarchical diffusion and adoption to the horizontal co-production of technologies and practices (Schiller et al., 2023).

SRI and ZBNF witnessed different degrees of policy adoption at the national level. SRI was primarily adopted at the state level of policymaking, thanks to the initial impetus provided by CSOs. At the national level, the SRI was supported peripherally through its inclusion in the NFSM and, to some degree, by promotion with the support of NABARD. Moreover, its inclusion at the national level was driven by the yield potential narrative rather than the larger narrative of agroecology's emergence as a response to agrarian crisis. In contrast, ZBNF, or natural farming, saw a firmer push by the union government, first with the BKPK program and later with the creation of NMNF. The financial support for this policy push, however, remains meager. The NMNF's budgetary allocation was a modest ₹600 crore, which constituted less than 0.5% of the MOAFW's annual budget of ₹1.37 lakh

[19] Policies, institutions, and knowledge entities are various components of the Indian agri-food system. Indian agri-food system is heavily influenced by the input-intensive industrial paradigm, which was introduced through the Green Revolution in the 1960s. The Green Revolution aimed at increasing productivity through modern agricultural inputs such as high-yielding variety (HYV) seeds, synthetic fertilizers, pesticides, irrigation, and machinery, which had a detrimental impact on ecological systems.

crore in FY 2025–26.[20] A more sobering fact is that the union government's fertilizer subsidy budget for FY 2025–26 is ₹1.56 lakh crore, which is higher than the union agriculture budget (Juneja & Gulati, 2025). The fertilizer subsidy reinforces input-intensive industrial agriculture. Therefore, agroecology requires a manyfold increase in budgetary allocation to compete with the dominant input-intensive paradigm. Zero-budget ought not to mean a reduction in public investment in agriculture; it involves a reorientation of policy priorities that the knowledge networks—mentioned in the earlier paragraphs—are going to facilitate.

Both SRI and ZBNF are positioned as solutions to the agrarian crisis and are considered necessary innovations for transitioning to sustainability, thus achieving the SDGs (Thakur et al., 2022; Tripathi et al., 2018). However, such a celebratory view becomes somber when questions of equity in efforts, benefits, and access to resources are examined. Agroecology's engagement with the existing agrarian structure is imperative to understanding the possibilities and ramifications of widespread adoption of agroecology. Therefore, it is essential to critically examine agroecology's engagement with issues of labor, gender, and resources, including land, water, livestock, and the commons.

## References

Abrol, D. (2023). Agroecology and agrarian transitions: Current debate in India. *Agrarian South: Journal of Political Economy: A triannual Journal of Agrarian South Network and CARES, 12*, 161–186.

Ahluwalia, M. S. (2011). Prospects and policy challenges in the twelfth plan. *Economic and Political Weekly*, 88–105.

Basu, S. (2009). *In the name of Sri: Retrospection on the spread of Sri in Andhra Pradesh, India*. Wageningen University, Wageningen.

Basu, S., Jongerden, J., & Ruivenkamp, G. (2018). Understanding the emergence of a hybrid knowledge production discourse: The case of the generation challenge Programme (Gcp) drought tolerant Rice research in India. *Njas-Wageningen Journal Of Life Sciences, 85*, 21–31.

Basu, S., & Leeuwis, C. (2012). Understanding the rapid spread of system of Rice intensification (Sri) in Andhra Pradesh: Exploring the building of support networks and media representation. *Agricultural Systems, 111*, 34–44.

Biswas, B. (2010). *System of Rice intensification: Success stories of farmers*.

Cáceres, D. M., Silvetti, F., & Diaz, S. (2016). The rocky path from policy-relevant science to policy implementation—A case study from the south American Chaco. *Current Opinion in Environmental Sustainability, 19*, 57–66.

CSTEP. (2019). *Life cycle assessment of Zbnf and non-Zbnf: A study in Andhra Pradesh*. Center for Study of Science, Technology and Policy.

Das, S., Khurana, M., & Gulati, A. (2024). *Zero budget natural farming implications for sustainability, profitability, and food security*. Nabard Research Study Nabard and Icrier.

[20] https://www.downtoearth.org.in/economy/budget-2025-26-major-boost-to-national-mission-on-natural-farming

Dhar, S., Barah, B., Vyas, A. K., & Uphoff, N. (2016). Comparing system of wheat intensification (Swi) with standard recommended practices in the northwestern plain zone of India. *Archives of Agronomy and Soil Science, 62*, 994–1006.

Directorate Of Rice Research. (2009). *Interactive policy dialogue on up-scaling Sri*. Angrau.

Dobermann, A. (2004). A critical assessment of the system of Rice intensification (Sri). *Agricultural Systems, 79*, 261–281.

Dorin, B. (2022). Theory, practice and challenges of agroecology in India. *International Journal of Agricultural Sustainability, 20*, 153–167.

FAO. (2018). *Scaling up agroecology initiatives: Transforming food and agricultural systems in support of the SDGS*. Food and Agricultural Organization of the United Nations.

FAO. (2021). *Zero budget natural farming (ZBNF) in India*. Food and Agricultural Organization of the United Nations. Retreived August 2, 2025 from https://www.fao.org/agroecology/database/detail/en/c/1417806/

Gathorne-Hardy, A., Reddy, D. N., Venkatanarayana, M., & Harriss-White, B. (2016). "System of Rice Intensification provides environmental and economic gains but at the expense of social sustainability—A multidisciplinary analysis in India." *Agricultural Systems, 143*, 159–168.

Geels, F. W., Kern, F., & Clark, W. C. (2023). Sustainability transitions in consumption-production systems. *Proceedings of the National Academy of Sciences, 120*, E2310070120.

Gliessman, S. (2018). Defining agroecology. *Agroecology and Sustainable Food Systems, 42*, 599–600.

Gupta, G., Dhar, S., Kumar, A., Kamboj, N. K., & Kumar, V. (2018). System of crop intensification integrated management of crops for improving sustainability and resilience to climate change. *Indian Farming, 68*.

Hajer, M. A. (1995). *The politics of environmental discourse: Ecological modernization and the policy process*. Clarendon Press.

Holt-Giménez, E., & Altieri, M. A. (2013). Agroecology, food sovereignty, and the new green revolution. *Agroecology and Sustainable Food Systems, 37*, 90–102.

Jaacks, L. M., Serupally, R., Dabholkar, S., Venkateshmurthy, N. S., Mohan, S., Roy, A., Prabhakaran, P., Smith, B., Gathorne-Hardy, A., & Veluguri, D. (2022). Impact of large-scale, government legislated and funded organic farming training on pesticide use in Andhra Pradesh, India: A cross-sectional study. *The Lancet Planetary Health, 6*, E310–E319.

Juneja, R., & Gulati, A. (2025). Agriculture budget 2025–26: Missed opportunity for reform. *Economic and Political Weekly, 60*, 48–51.

Keeley, J., & Scoones, I. (2014). *Understanding environmental policy processes: Cases from Africa*. Routledge.

Khadse, A., Rosset, P. M., Morales, H., & Ferguson, B. G. (2018). Taking agroecology to scale: The zero budget natural farming peasant movement in Karnataka, India. *The Journal of Peasant Studies, 45*, 192–219.

Klerkx, L., Aarts, N., & Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural Systems, 103*, 390–400.

Klerkx, L., Van Mierlo, B., & Leeuwis, C. (2012). Evolution of systems approaches to agricultural innovation: Concepts, analysis and interventions. In *Farming systems research into the twenty-first century: The new dynamic* (pp. 457–483).

Kumar, R. (2019). India's green revolution and beyond: Visioning agrarian futures on selective readings of agrarian pasts. *Economic and Political Weekly, 54*, 41–48.

Maat, H., & Glover, D. (2012). Alternative configurations of agronomic experimentation. In J. Sumberg & J. Thompson (Eds.), *Contested agronomy: Agricultural research in a changing world*. Routledge.

Mcdonald, A. J., Hobbs, P., & Riha, S. (2006). Does the system of Rice intensification outperform conventional best management?: A synopsis of the empirical record. *Field Crops Research, 96*, 31–36.

MOAFW. (2025). *Promotion of natural farming under National Mission on Natural Farming*. Pib.

Nirmala, B., Tuti, M., Mahender Kumar, R., Waris, A., Muthuraman, P., Parmar, B., & Vidhan Singh, T. (2021). Integrated assessment of system of rice intensification vs. conventional method of transplanting for economic benefit, energy efficiency and lower global warming potential in India. *Agroecology and Sustainable Food Systems, 45*, 745–766.

Orozco-Meléndez, J. F., & Paneque-Gálvez, J. (2022). A role for grassroots innovation toward agroecological transitions in the global south? Evidence From Mexico. *Ecological Economics, 201*, 107582.

Palanisami, K., Karunakaran, K., Amarasinghe, U., & Ranganathan, C. (2013). Doing different things or doing it differently? Rice intensification practices in 13 states of India. *Economic and Political Weekly*, 51–58.

Pandey, P., & Cabral, L. (2025). Transformational agroecology: The making and unmaking of zero budget natural farming in India. *Science, Technology and Society, 30*, 259–278.

Pant, L. P. (2016). Paradox of mainstreaming agroecology for regional and rural food security in developing countries. *Technological Forecasting and Social Change, 111*, 305–316.

Patnaik, U. (2003). Global capitalism, deflation and agrarian crisis in developing countries. *Journal of Agrarian Change, 3*, 33–66.

Pigford, A.-A. E., Hickey, G. M., & Klerkx, L. (2018). Beyond agricultural innovation systems? Exploring an agricultural innovation ecosystems approach for niche design and development in sustainability transitions. *Agricultural Systems, 164*, 116–121.

Prasad, C. (2006). *System of Rice intensification in India: Innovation history and institutional challenges*. WWF and XIMB.

Prasad, C., & Sen, D. (2010). The new commons in agriculture: Lessons from the margins and Sri in India. In *Innovation and sustainable development in agriculture and food*. ISDA.

Prasad, C. S. & Barah, B. (2013). *Upscaling Sri: Unpacking innovation, investment and institutions*. LEISA India, March, 16–19.

Prasad, C. S., Chakraborty, A., & Dutta, D. (2024). The need for ground-up transitions: Exploring the knowledge politics of agroecology in Gujarat, India. *Agroecology and Sustainable Food Systems, 48*, 688–712.

Prasad, S. C. (2016). Innovating at the margins: The system of Rice intensification in India and transformative social innovation. *Ecology and Society, 21*.

Raina, R. (2015). Knowing and administering food: How do we explain persistence. In C. Reddy (Ed.), *Food security and food production institutional challenges in the governance domain*. Cambridge Scholars.

Ramakumar, R. & Arjun, S. V. (2019). *Stirring up the truth about zero budget natural farming*. The Hindu Retrieved August 3, 2025 from https://www.thehindu.com/opinion/lead/stirring-up-the-truth-about-zbnf/article29620843.ece

Ramdas, S. R., & Pimbert, M. P. (2024). A cog in the capitalist wheel: Co-opting agroecology in South India. *The Journal of Peasant Studies, 51*, 1251–1273.

Samal, P. (2013). Growth in production, productivity, costs and profitability of Rice in India during 1980-2010. In P. K. Shetty, M. R. Hegde, & M. Mahadevappa (Eds.), *Innovations in Rice production*. National Institute of Advanced Studies.

Schiller, K. J., Klerkx, L., Salazar Centeno, D. J., & Poortvliet, P. M. (2023). Developing the Agroecological niche in Nicaragua: The roles of knowledge flows and intermediaries. *Proceedings of the National Academy of Sciences of the United States of America, 120*, E2206195120.

Sinclair, T. R. & Cassman, K. G. (2004). *Agronomic Ufos*.

Singh, P. K. (2019). *Situating agroecology in the agrarian discourse: System of rice intensification in South Bihar.* M.Phil in Development Studies, University of Calcutta.

Sorensen, T., Si, Z., Scott, S., & Sridharan, T. (2025). The implications of agroecology for meeting the sustainable development goals (Sdgs): A scoping review. *Agroecology and Sustainable Food Systems*, 1–33.

Stoop, W. A., Uphoff, N., & Kassam, A. (2002). A review of agricultural research issues raised by the system of Rice intensification (Sri) from Madagascar: Opportunities for improving farming systems for resource-poor farmers. *Agricultural Systems, 71*, 249–274.

Suchiradipta, B., & Raj, S. (2015). Agricultural innovation systems (Ais): A study of stakeholders and their relations in system of Rice intensification (Sri). *The Journal of Agricultural Education and Extension, 21*, 343–368.

Suryavanshi, P., Singh, Y., Prasanna, R., Bhatia, A., & Shivay, Y. (2013). Pattern of methane emission and water productivity under different methods of Rice crop establishment. *Paddy and Water Environment, 11*, 321–329.

Tambe, S., Ballal, A., Tomar, R., Wyborn, C., Defries, R., Ganguly, S., & Scarlett, L. (2023). Bridging science, policy and practice for sustainability: Towards a conceptual framework. *Environmental Science & Policy, 145*, 208–216.

Taylor, M., & Bhasme, S. (2019). The political ecology of Rice intensification in South India: Putting Sri in its places. *Journal of Agrarian Change, 19*, 3–20.

Thakur, A. K., Mandal, K. G., Mohanty, R. K., & Uphoff, N. (2022). How agroecological rice intensification can assist in reaching the sustainable development goals. *International Journal of Agricultural Sustainability, 20*, 216–230.

Tittonell, P. (2020). Assessing resilience and adaptability in agroecological transitions. *Agricultural Systems, 184*, 102862.

Tripathi, S., Shahidi, T., Nagbhushan, S., & Gupta, N. (2018). *Zero budget natural farming for the sustainable development goals, Andhra Pradesh, India*. Council of Energy Environment and Water (Ceew).

Uphoff, N. (2003). Higher yields with fewer external inputs? The system of rice intensification and potential contributions to agricultural sustainability. *International Journal of Agricultural Sustainability, 1*, 38–50.

Uphoff, N., Kassam, A., & Stoop, W. (2008). A critical assessment of a desk study comparing crop production systems: The example of the 'system of Rice Intensification' versus 'best management practice'. *Field Crops Research, 108*, 109–114.

Vanloqueren, G., & Baret, P. V. (2009). How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations. *Research Policy, 38*, 971–983.

Veluguri, D., Bump, J. B., Venkateshmurthy, N. S., Mohan, S., Pulugurtha, K. T., & Jaacks, L. M. (2021). Political analysis of the adoption of the zero-budget natural farming program in Andhra Pradesh, India. *Agroecology and Sustainable Food Systems, 45*, 907–930.

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# Chapter 12
# From Export-Driven Agriculture to Food Sovereignty: Integrating Agroecology in Morocco's Agricultural Transition

**Si Bennasseur Alaoui**

**Abstract** This chapter takes a thoughtful and critical look at how Morocco's agricultural landscape has evolved. It tracks the country's shift from a model focused on exports and monoculture to one that emphasizes food sovereignty and agroecological change. The chapter places recent policy changes in the context of a broader historical trajectory, shaped by government-led modernization efforts like the Green Morocco Plan, alongside challenges such as increasing water scarcity and the effects of climate change. These factors have put more pressure on land and the livelihoods of rural communities. By weaving together policy analysis, historical context, and research from different farming systems (including rainfed, irrigated, and oasis agriculture), the chapter reveals how water-intensive export crops, uneven resource distribution, and environmental damage have hit small-scale farmers, rural families, and women hardest, exacerbating social and regional inequalities. This discussion highlights the crucial role of agrobiodiversity in building resilient agroecosystems and ensuring food security. It focuses on the importance of preserving and using indigenous crop varieties, local livestock breeds, and traditional mixed farming practices that support both ecological balance and cultural heritage. The discussion also explores the growing potential of community-supported agriculture (CSA) and related initiatives aimed at localizing food systems. These efforts seek to encourage inclusive market participation, promote climate-smart and organic farming practices, and empower marginalized communities—particularly women and youth—by involving them in more participatory forms of food governance. By bringing together insights from agronomy, rural sociology, gender studies, and political ecology, this chapter emphasizes that meaningful progress towards food sovereignty requires more than just targeted policy interventions and inclusive national food strategies. It calls for stronger collaboration across different levels—between government agencies, local authorities, grassroots organizations, and global partners—underpinned by research that is both interdisciplinary and responsive to the local context. The chapter also highlights existing knowledge gaps, such as the limited regional and sectoral focus, a lack of attention to gender and equity,

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and the absence of strong economic and environmental monitoring tools to evaluate shifts away from export-driven models. The chapter wraps up with a set of practical recommendations that emphasize the need to incorporate agrobiodiversity into agricultural policy, expand CSA and other solidarity-based market models, and establish participatory governance structures. It ultimately calls for a broad shift in perspective, one that combines agroecological practices with social justice and equity, aiming to create resilient, fair, and sustainable food systems for all Moroccan citizens.

**Keywords** Morocco · Agriculture · Sovereignty · Agrobiodiversity · Agroecology · Farmers · Women · Resilience · Policy · Sustainability · Equity · CSA (community-supported agriculture) · ecosystem

## 12.1 Introduction

### *12.1.1 Brief Overview of the Moroccan Agricultural Landscape*

Morocco's agricultural landscape is characterized by its diverse climates and varied topographies, which allow for the cultivation of a wide range of crops. The country's agriculture largely consists of cereals, vegetables, fruits, and livestock, all of which are vital for both the national economy and food security. To modernize the agricultural sector, the Moroccan government has implemented various policies, including the "Green Morocco Plan 2008-2018", aimed at enhancing productivity and sustainability. However, the sector faces numerous challenges, including water scarcity, soil degradation, and the dominance of export-oriented monocultures. These factors have contributed to rural poverty, food insecurity, and environmental issues. Additionally, incorporating traditional practices with the integration of modern techniques is essential for adapting to climatic challenges and ensuring resilience in this sector.

### *12.1.2 The Moroccan Agricultural Context: Historical Overview, Current Challenges, and Opportunities*

The agricultural landscape in Morocco is deeply rooted in its history, with practices dating back to the medieval period. During this time, irrigation systems and terraced farming were developed in response to the arid climate. Over the years, agriculture has played a crucial role in Morocco's economy; however, the sector faces several contemporary challenges, including water scarcity, land degradation, and the

impacts of climate change. These issues threaten the livelihoods of millions of people involved in the sector and call for urgent reforms. Despite these challenges, opportunities exist for growth, particularly through technological advancements and sustainable practices that can enhance productivity and resilience (Jabir & Falih, 2020).

### *12.1.3 Agrobiodiversity and Its Role in Sustainable Agriculture*

Agrobiodiversity plays a vital role in promoting sustainable agriculture in Morocco, particularly in the context of climate change and food security. The diverse array of plant and animal species within agricultural systems allows for greater resilience against pests and diseases while enhancing ecosystem stability. According to Moussadek et al. (2020), traditional Moroccan agricultural practices, which emphasize the cultivation of local varieties and mixed cropping systems, contribute to maintaining agrobiodiversity that not only supports local cuisines but also preserves cultural heritage. Furthermore, agrobiodiversity is essential for adapting to changing environmental conditions, as it provides a genetic reservoir that can help farmers develop more resilient crop varieties. The conservation and sustainable management of agrobiodiversity in Morocco thus not only enhance productivity and food security but also support agroecosystem health and biodiversity conservation (FAO, 2019).

### *12.1.4 Community-Supported Agriculture Models and Their Potential for Food Security and Equity*

Community-supported agriculture (CSA) models in Morocco are emerging as a promising strategy to enhance food security and equity among local populations. These models foster direct relationships between consumers and farmers, enabling communities to support local agriculture and gain access to fresh, seasonal produce. CSAs offer small-scale farmers stable incomes and improved market access, which reduces their vulnerability to market fluctuations and increases their resilience to economic shocks. Moreover, CSAs empower marginalized groups, including women and youth, by providing opportunities for participation in sustainable farming practices and cooperative management. This collaborative framework not only enhances food sovereignty but also promotes social equity by ensuring that food systems are more inclusive and reflective of community needs. Hence, CSAs hold significant potential for addressing both food security and social inequalities in Morocco's agricultural landscape.

### *12.1.5 The Impact of Export-Oriented Agriculture on Small-Scale Farmers and the Environment*

Export-oriented agriculture in Morocco has profound implications for small-scale farmers and the environment, presenting both opportunities and challenges. The expansion of export crops, such as berries and citrus fruits, has increased income for some farmers by integrating them into lucrative global markets.

However, this focus on high-value export products often marginalizes smallholders who lack the necessary resources and infrastructure to compete (Benhammou, 2021). These pressures can lead to unsustainable farming practices, such as excessive use of water and pesticides, resulting in soil degradation and biodiversity loss. Moreover, the shift towards monoculture farming to meet export demand can negatively impact local ecosystems and increase vulnerability to diseases and climate variability.

Thus, while export-oriented agriculture provides economic benefits, it also raises critical concerns regarding environmental sustainability and equity among small-scale farmers in Morocco.

### *12.1.6 Gender and Agriculture: The Specific Challenges Faced by Women Farmers*

In Morocco, women farmers face a multitude of challenges that hinder their participation and success in agriculture, despite their critical role in food production and household livelihoods. Women in rural areas often have limited access to land ownership and credit, which restricts their capacity to invest in and improve agricultural practices. Cultural norms and traditions further exacerbate these inequalities, as women are frequently marginalized in decision-making processes, at both the household and the community levels. Additionally, women farmers often face a lack of access to education and training programmes that could enhance their agricultural skills and knowledge.

These factors, coupled with the increasing impacts of climate change, pose significant threats to the resilience and productivity of women-led farming systems in Morocco, necessitating targeted interventions that promote gender equity and empower women in agriculture (World Bank, 2015).

## 12.2 Methodology

This paper draws upon a multifaceted approach, integrating rigorous academic research with unique insights gained from personal experience and field observations. A comprehensive literature review served as the foundation, providing a

comprehensive understanding of existing theories, methodologies, and empirical findings related to agroecology and food sovereignty in Morocco. This theoretical framework is then further enriched by lived experiences, offering a nuanced perspective on the social, cultural, and emotional dimensions of the topic. This integrated approach, combining scholarly rigour with personal authenticity, has resulted in a chapter that is both theoretically informed and deeply grounded in real-world experiences.

## 12.3 Results

### *12.3.1 Characterization of the Agricultural Landscape and Farming Systems*

Morocco's agricultural landscape is diverse, influenced by the country's varied climate, terrain, and long-standing agricultural traditions. The agriculture sector can be divided into three main systems: rainfed, irrigated, and oasis farming. Each system has its own unique characteristics, challenges, and role in supporting national food security and rural livelihoods.

#### 12.3.1.1 Rainfed Agriculture

Rainfed farming continues to be the main agricultural method in Morocco, especially in the northern, central, and mountainous areas of the country. This farming technique is vital for growing key crops like wheat and barley, which are not only essential for the Moroccan diet but also form the backbone of the country's agricultural economy. In addition to these cereals, rainfed agriculture is also crucial for growing legumes such as lentils and chickpeas, which play an important role in ensuring food security and supporting the nutritional needs of the population.

Although rainfed farming is a crucial part of Morocco's agricultural landscape, it faces considerable challenges because it depends on natural rainfall patterns. The system is particularly vulnerable to climate change, especially the unpredictable nature of rainfall, which can significantly affect crop yields. During years with inadequate or irregular rainfall, crop production is often severely impacted, leading to yields that fluctuate and may not meet the needs of local consumers or the export market.

The effects of climate change are making these challenges even worse, as droughts are becoming more frequent and severe, putting the long-term viability of rainfed farming at risk. Farmers in these areas often have to rely on adaptive strategies, like diversifying crops or using traditional water conservation methods. However, these approaches may not always be enough to handle the growing unpredictability of weather patterns. As a result, there is an increasing need for more

resilient farming systems, better water management practices, and climate-smart techniques to ensure the future stability and sustainability of Morocco's rainfed agriculture.

#### 12.3.1.2 Irrigated Agriculture

Irrigated agriculture is a cornerstone of Morocco's agricultural economy, making up about 15% of the country's total farmland. Despite occupying only a small fraction of the land, it contributes over 45% of the total agricultural output, mainly due to its higher productivity compared to rainfed agriculture. These irrigated regions are crucial for maintaining food security in the country, as they are responsible for producing a large portion of the nation's cereals, fruits, vegetables, and fodder.

Morocco has five primary irrigated areas, each specializing in different types of crops: the Doukkala, Tadla, Haouz, Gharb, and Souss-Massa regions. These areas benefit from advanced irrigation systems, such as surface and drip irrigation, which allow farmers to grow a wide range of crops year-round, regardless of rainfall. In Doukkala and Tadla, the focus is on growing cereals like wheat and corn. Haouz and Gharb, on the other hand, are major producers of fruits and vegetables, including tomatoes, peppers, and lettuce.

Souss-Massa, located in the southern part of Morocco, stands out for its significant contribution to the country's horticultural exports. This region has become a key agricultural hub, known for high-value crops such as citrus fruits (oranges, mandarins, and lemons) and early-season vegetables like tomatoes and peppers (Ministère de l'Agriculture, 2020). These crops are exported to European and international markets, playing a key role in Morocco's agricultural revenue. The region's irrigation systems, mainly supplied by dams, support intensive farming in an otherwise dry region, meeting both local and global demand for fresh produce.

However, relying on irrigation also presents challenges, particularly when it comes to water scarcity. Morocco's irrigation systems face pressure from various water demands, including domestic, industrial, and urban use. With climate change adding to the problem—causing reduced rainfall and higher temperatures—sustainable water management practices are becoming more essential. Efforts are underway to enhance irrigation efficiency, adopt water-saving technologies, and diversify crops to cope with these challenges, ensuring that Morocco's irrigated regions continue to thrive in the long term.

#### 12.3.1.3 Oasis Farming Systems

Oasis farming is a traditional practice deeply rooted in Morocco, especially in the Drâa, Tafilalet, Ziz valleys, Tata, Akka, and Figuig regions. These areas are marked by dry climates and limited rainfall, which makes irrigation vital for successful agriculture. Oasis farming mainly relies on spate irrigation, a technique that channels water from seasonal floods into fields. Additionally, traditional methods like

khettaras—underground canals designed to tap into underground water—are also used. This allows farming to flourish even in regions where surface water is scarce (Ait-El-Mokhtar et al., 2020).

Oasis farming plays an essential role in the Moroccan economy, particularly in the country's remote desert regions, where it supports local livelihoods and preserves cultural traditions. One of the key crops of oasis farming is the date palm, a staple that is central to food security, local commerce, and cultural practices. The dates are harvested not only for local consumption but also for export, making them an important agricultural export product. In addition to dates, olives are commonly grown, providing food and valuable olive oil for local markets.

Other important crops grown in these regions include alfalfa, wheat, and henna, each of which plays a crucial role in the local economy. Alfalfa is used primarily as livestock feed, supporting Morocco's pastoral farming traditions. Henna, meanwhile, is grown for its cultural significance in Moroccan rituals, particularly in body art and cosmetics. These crops are deeply tied to local traditions, providing both food and employment opportunities for the people living in these regions.

However, the sustainability of oasis farming faces growing challenges due to water scarcity and the spread of desertification. Climate change, with its erratic rainfall and rising temperatures, is intensifying these problems, putting immense pressure on the traditional irrigation systems. This calls for sustainable water management practices and new innovations to protect the vital water resources that make oasis farming possible. Additionally, there is a growing need to diversify crops and incorporate more resilient farming practices to ensure the continued survival and success of oasis agriculture as Morocco faces a rapidly changing climate.

#### 12.3.1.4 Challenges and Sustainability Concerns

Despite the ecological and socio-economic significance of these systems, Moroccan agriculture is facing increasing challenges from water scarcity, land degradation, demographic shifts, and climate change, all of which threaten its long-term resilience and productivity. As a result, there is a growing push to develop drought- and salt-tolerant crop varieties, expand water-saving technologies, and implement integrated management practices.

### *12.3.2 Analysis of Agrobiodiversity Levels and Its Relationship to Food Security*

The analysis of agrobiodiversity levels in Morocco reveals a strong relationship between the diversity of agricultural species and food security outcomes. The country's geographic and climatic variations support a rich tapestry of traditional crops and livestock breeds, which contribute directly to local diets and nutrition (Bernis &

Fonteneau, 2023). According to FAO (2021), high levels of agrobiodiversity enable farmers to adapt to environmental stresses, such as climate change and water scarcity, thereby reducing risks to food production. Conserving indigenous varieties, such as local wheat, barley, and food legumes, not only ensures dietary diversity but also strengthens the resilience of farming systems against pests and diseases (Ouarghidi & Ben-Meiron, 2018). Furthermore, promoting agrobiodiversity through community-led initiatives can enhance access to nutritious food in rural areas, fostering food sovereignty and improving overall food security (MBLA, 2020). Hence, integrating agrobiodiversity into agricultural policies and practices is essential for achieving sustainable food security in Morocco.

### *12.3.3 Assessment of the Potential of Community Supported Agriculture Models in the Moroccan Context*

CSA models present significant potential to enhance food security, support local economic development, and foster sustainable farming practices in Morocco. According to Hamouchene and Minio-Paluello (2022), CSA initiatives create direct connections between consumers and farmers, thus promoting awareness of local food systems and encouraging community participation in agricultural production. These models can empower small-scale farmers by providing them with a more stable income through upfront payments from subscribers, which reduces their vulnerability to market fluctuations (Hamouchene & Minio-Paluello, 2022). Additionally, CSAs emphasize the cultivation of organic and traditional agricultural products, which contributes to biodiversity conservation and environmental sustainability. This aligns with Morocco's commitment to sustainable agricultural practices (Chibane, 2022). Moreover, by fostering social equity and inclusivity, particularly among marginalized groups like women and youth, CSAs can play a crucial role in rural development and food sovereignty (Hamouchene & Minio-Paluello, 2022). Therefore, promoting and expanding CSA models in Morocco could significantly enhance the resilience and sustainability of the agricultural sector.

### *12.3.4 Evaluation of the Impact of Export-Oriented Agriculture on Small-Scale Farmers and the Environment*

The evaluation of export-oriented agriculture in Morocco highlights significant impacts on both small-scale farmers and the environment. While export-oriented crops, such as fruits and vegetables, have increasingly attracted investment and created economic opportunities, they often disproportionately benefit larger agribusinesses, leaving small-scale farmers at a disadvantage (World Bank, 2021). These

farmers frequently face challenges such as high production costs, market entry barriers, and competition that threaten their livelihoods.

Additionally, the agricultural intensification associated with export crops can lead to detrimental environmental consequences, including soil degradation, excessive water usage, and biodiversity loss due to monoculture practices (Molle, 2017). Furthermore, reliance on chemical inputs to maximize yields can result in pollution and health risks for local communities. Therefore, while export-oriented agriculture has the potential to drive economic growth in Morocco, it necessitates careful management and policy interventions to safeguard the interests of small-scale farmers, protect the environment, and preserve the scarce water resources.

### *12.3.5 Gender Analysis of the Agricultural Sector*

A gender analysis of the agricultural sector in Morocco reveals significant disparities in access to resources, decision-making power, and benefits between men and women farmers. Women comprise about 50% of the agricultural workforce, yet they often face systemic barriers that limit their effective participation and contribution to agricultural productivity (FAO, 2011). Women typically have less access to land ownership, credit, and agricultural extension services, which constrains their ability to adopt modern techniques and improve their economic status. This situation is exacerbated by cultural norms that prioritize men's roles in agriculture and decision-making processes, thereby depriving women of their rightful voice and agency (Adnane, 2018). Furthermore, women in Morocco engage primarily in subsistence farming, while men dominate cash crop production for export, leading to gendered differences in income and food security. Addressing these inequities through targeted policies and programmes is crucial for enhancing the role of women in agriculture and achieving sustainable development in Morocco.

## 12.4 Discussion

### *12.4.1 The Interconnections Between Agrobiodiversity, Community-Supported Agriculture, Food Security, and Gender Equity*

In the Moroccan context, the interconnections between agrobiodiversity, CSA, food security, and gender equity are crucial for promoting sustainable development. Agrobiodiversity enhances resilience and adaptability in farming systems by providing a variety of crops and livestock that can thrive under diverse climatic conditions (Ouarghidi & Ben-Meiron, 2018). When coupled with CSA models, these diverse agricultural practices foster direct relationships between producers and

consumers, ensuring that local farmers, including women, gain better access to markets and stable income. Integrating CSA can empower women, as it often emphasizes participatory approaches that enable them to play a central role in decision-making and improve their economic independence. Furthermore, by promoting the cultivation of indigenous varieties through CSA, communities can enhance food security and nutritional diversity, directly benefiting local populations. Thus, the synergy between agrobiodiversity, CSA, food security, and gender equity can create a more sustainable and equitable agricultural system in Morocco.

### *12.4.2 The Potential of Agroecological Approaches to Address the Challenges Faced by Moroccan Agriculture*

Agroecological approaches present a viable solution to the myriad challenges that Moroccan agriculture faces, including water scarcity, soil degradation, and the impacts of climate change. According to Altieri (2018), agroecology emphasizes sustainable farming practices that enhance biodiversity, improve soil health, and increase resilience to environmental changes, which are critical in a country where traditional farming systems are under significant pressure. Research conducted by Moussadek, El Gharyani, and Moutaouakkil (2021) highlights that agroecological practices, such as crop rotation, intercropping, and organic fertilization, not only increase agricultural productivity but also reduce the dependency on chemical inputs and promote environmental sustainability. Additionally, adopting agroecological methods fosters social equity by empowering local communities and smallholder farmers to engage in sustainable food production (Wezel et al., 2014). Furthermore, these approaches can enhance food sovereignty by preserving traditional crop varieties and promoting local food systems, effectively addressing food security issues in Morocco. Overall, the transition towards agroecology in Morocco holds the potential to create resilient agricultural systems that are both economically viable and environmentally sustainable.

### *12.4.3 Policy Recommendations for Supporting the Transition to a More Sustainable and Equitable Food System*

To facilitate Morocco's shift towards a more sustainable and equitable food system, it is essential to develop a well-rounded set of policy recommendations. These recommendations should be firmly rooted in the latest research and practical experiences. One key approach is the adoption of agroecological practices, including diverse crop rotation, the use of organic fertilizers, and intercropping. These practices not only promote the health of ecosystems but also enhance agricultural productivity. Additionally, they help reduce the dependency on chemical inputs,

which in turn reinforces long-term food security and reinforces resilience to climate change.

A key recommendation for Morocco's agricultural development is to increase targeted support for smallholder farmers. This support should include equitable subsidies, improved access to markets, better credit opportunities, and enhanced technical training (Benayad et al., 2024). These initiatives are essential in addressing rural-urban disparities, stimulating local economies, reducing poverty, and protecting farmers from the impact of price fluctuations. Furthermore, it is crucial to develop and implement inclusive food policies that prioritize the needs of marginalized groups, particularly women and youth, while ensuring equitable food access across diverse ecological regions.

Community-supported agriculture (CSA) models, along with local food cooperatives, are increasingly recognized as powerful tools for improving market access, promoting agrobiodiversity, and strengthening direct relationships between producers and consumers. These models can play a crucial role in empowering women, supporting food sovereignty, and fostering social capital—all of which are essential for achieving equitable development.

Achieving effective transformation relies on strong collaboration between government agencies, local authorities, grassroots organizations, and international bodies, as highlighted by the High Atlas Foundation (2025). Cross-sector initiatives, such as training in climate-smart agriculture, promoting participatory governance, establishing local seed banks, and implementing environmental monitoring, are crucial for building resilience and adaptability in the face of change.

By implementing these evidence-based strategies, Morocco has the opportunity to develop a food system that is not only productive and resilient but also fair and inclusive. This approach will help address both environmental and economic challenges, ensuring a sustainable and equitable future.

### *12.4.4 Limitations of the Study and Suggestions for Future Research*

While the study "From Export Fields to Food Sovereignty: A Moroccan Perspective" provides important insights into agricultural transition and food sovereignty, it also presents certain limitations that should be considered in future research. A key limitation is its reliance on qualitative data drawn from a narrow set of case studies, which limits the generalizability of its conclusions to the diverse agricultural landscapes of Morocco. Furthermore, the study tends to make broad recommendations without fully accounting for the country's varying climate zones, cropping systems, and traditional farming practices, such as rainfed, irrigated, and oasis agriculture.

Additionally, the report does not adequately address regional disparities in access to resources or the issue of gender equity—both of which are critical factors influencing the success of food sovereignty initiatives in practice. Another significant

limitation is the absence of comprehensive economic and market analysis, particularly regarding the financial feasibility and infrastructure challenges involved in transitioning from export-oriented agriculture to a food sovereignty model.

Another limitation of the study is its insufficient focus on participatory approaches that involve local communities, particularly women and youth. These groups bring invaluable knowledge and their engagement is crucial for ensuring the sustainability of food systems. Moreover, environmental monitoring, including the assessment of water usage, soil health, and agrobiodiversity, is not adequately emphasized, yet it is essential for understanding the long-term impacts of agricultural transitions.

For future research, the following recommendations should be considered:

- Use mixed-method approaches, including quantitative surveys and longitudinal studies, to provide deeper insights.
- Broaden the geographic focus to include regions and farming systems that are currently underrepresented.
- Incorporate comprehensive economic modelling and market assessments to strengthen the analysis.
- Ensure that gender, equity, and participatory governance are integrated into both the analysis and methodology.
- Integrate environmental indicators to evaluate the sustainability and resilience of the systems under study.

By expanding both its analytical approach and methodological framework, future research will lay a stronger, more practical, and contextually relevant foundation for advancing food sovereignty in Morocco.

## 12.5 Conclusion

### *12.5.1 Summary of Key Findings*

The study "From Export Fields to Food Sovereignty: A Moroccan Perspective" provides valuable insights into pathways for transitioning Morocco's agricultural system towards food sovereignty. However, it is essential to recognize some limitations that could be addressed in future research. The study primarily relies on qualitative data and a small number of case studies, which limits the broader applicability of its findings across Morocco's diverse agro-ecological zones. Additionally, the lack of region-specific analysis may oversimplify the policy recommendations and their potential impact on areas such as Souss-Massa, Rif, and oasis farming systems, each of which faces unique challenges related to climate, water management, and cropping systems.

Another limitation of the study is the lack of comprehensive economic modelling and cost-benefit analysis regarding the feasibility of transitioning from export-driven monoculture to food sovereignty frameworks. This is particularly important

when considering factors such as market access, infrastructure, and resource limitations. Furthermore, the report could benefit from a deeper exploration of gender and equity dynamics, as women and marginalized groups are essential to rural food systems, yet they often encounter significant barriers to land ownership, access to training, and participation in decision-making processes.

Future research should aim to incorporate a wider range of mixed-method datasets, including both quantitative surveys and longitudinal studies, to capture changing trends over time. It would also be valuable to broaden the scope of case studies to include rainfed, irrigated, and oasis agriculture, along with participatory action research that involves diverse stakeholders. This approach would provide a more nuanced understanding of socio-economic and gendered dynamics. Furthermore, integrating environmental monitoring—such as tracking soil health, water use, and biodiversity—would help deepen our understanding of sustainability outcomes as Morocco works towards achieving food sovereignty.

In order to advance food sovereignty research in Morocco, it is essential to adopt interdisciplinary approaches, expand geographic coverage, conduct thorough economic analysis, and prioritize social inclusion. This will ensure that future research findings are not only specific to the local context but also practical and actionable for shaping policy and guiding practice.

### *12.5.2 Reiteration of the Importance of Agrobiodiversity and Community-Supported Agriculture for Achieving Food Sovereignty*

Agrobiodiversity and community-supported agriculture (CSA) are essential strategies for advancing food sovereignty in Morocco, as highlighted by both scholars and practitioners in recent studies. Bendada et al. (2025) emphasize that agrobiodiversity—the conservation and use of a wide variety of crops, livestock breeds, and farm trees—strengthens resilience to environmental challenges and enhances local diets. Research conducted in high-diversity regions, such as the Triffa Plain and the Atlas Mountains, shows that integrating traditional varieties and organic farming practices not only improves soil health and boosts ecosystem functions but also helps preserve cultural and ecological heritage, particularly in marginalized communities.

Community-supported agriculture (CSA) initiatives, as explored by Lass (2024) and local organizations like Dar Si Hmad (Anti-Atlas Mountains), play a crucial role in strengthening the economic and social connections between farmers and consumers. These initiatives promote fair compensation and foster deeper mutual engagement in food systems. Research on Moroccan CSA models shows that consumer investment and shared risk strategies help diversify farm incomes, reduce vulnerability to market fluctuations, and encourage the adoption of agroecological practices, such as companion planting and organic fertilization.

CSA and agrobiodiversity have significant positive effects on social cohesion and inclusion. Women's cooperatives and local producers' groups, as highlighted by MBLA (2025) and the High Atlas Foundation (2025), play a vital role in empowering marginalized communities. These groups enable women and other underserved populations to engage in decision-making processes, protect indigenous seed varieties, and restore multispecies agroecosystems, which are more resilient to drought and climate-induced shocks. Research shows that these approaches not only enhance energy efficiency but also improve ecosystem services and increase the availability of local food.

By investing in these interconnected systems, Morocco can build resilient, inclusive, and sustainable food networks that support food sovereignty, ecological integrity, and rural livelihoods for generations to come (FAO, n.d.).

### *12.5.3 Call for a Paradigm Shift Towards Agroecological Practices*

There is a clear and pressing need for a shift towards agroecological practices in Morocco to address the urgent challenges posed by climate change, food insecurity, environmental degradation, and growing socio-economic inequalities in the agricultural sector. As highlighted by Montoya et al. (2024) and Hakimi (2022), agroecology offers a transformative approach that not only enhances biodiversity but also improves soil health and promotes water conservation. This makes farming both economically feasible and ecologically sustainable, especially in Morocco's arid and semi-arid regions.

Research led by scholars such as Moussadek (2025) highlights the importance of combining traditional local knowledge with scientific innovation. This integration not only empowers smallholder farmers and rural communities but also ensures fair access to critical resources like land, water, and seeds. Practical recommendations from the field emphasize the value of practices such as crop rotation, companion planting, recycling organic manure, seed saving, and designing food forests—approaches that have been shown to enhance resilience and help protect against drought and market fluctuations.

A successful shift to agroecology requires collaboration among multiple stakeholders. Policymakers have a key role to play in supporting evidence-based policies and offering financial incentives, while partnerships between farmers, researchers, and civil society can foster the exchange of knowledge and drive innovation. Education and outreach efforts, including hands-on training and farmer-to-farmer exchanges, are essential for encouraging wider adoption of agroecological practices.

By adopting a clear and focused commitment to agroecological approaches, supported by scientific research and rooted in Morocco's rich agricultural traditions, the country can move towards establishing a more just, resilient, and food-sovereign system for all its citizens.

By maintaining a focused and consistent commitment to agroecological approaches, supported by scientific research and rooted in Morocco's rich agricultural heritage, the country can move towards building a more just, resilient, and food-sovereign system for all of its citizens.

### *12.5.4 Emphasize the Need for Further Research and Policy Support*

Recent studies, including the report "Food Sovereignty in Morocco" by Srairi (2025), as well as research by economists such as Akesbi (2023), highlight the significant socio-economic and environmental consequences of Morocco's shift towards an export-driven agricultural model. These impacts warrant urgent attention and further interdisciplinary research. The export-oriented approach, supported by policies like the Green Morocco Plan, has created a dual agricultural system in which large agribusinesses disproportionately benefit from state resources. Meanwhile, smallholder farmers and rural communities are increasingly vulnerable, relying more on imported commodities such as cereals, oils, and animal feed.

Given the pressures on water resources, soil health, and food sovereignty, studies by Bekkaoui et al. (2024) emphasize the urgent need for comprehensive policy frameworks that promote climate resilience and territorial equity in food production. Approaches such as conservation agriculture, crop diversification, and agroecology—highlighted in research published in *Frontiers* and through local Moroccan initiatives—have proven effective in enhancing biodiversity, restoring soil fertility, and countering the negative impacts of monoculture and the use of chemical inputs.

Moreover, policy reforms should prioritize investments in farmer education, local seed preservation, veterinary services, and collective animal health programmes, all of which are essential for empowering smallholder farmers and revitalizing rural economies. Effective food governance requires the integration of agricultural and food security strategies, ensuring equitable access to state support, and encouraging participatory decision-making that involves the voices of local producers and consumers. The academic literature consistently highlights that such inclusive frameworks not only enhance Morocco's resilience to market and climate shocks but also help preserve its agricultural heritage and cultural identity.

By incorporating research findings and implementing supportive policies at multiple levels, Morocco can work towards building a more sustainable, equitable, and locally rooted food system. Such a system would ensure food sovereignty for all citizens while safeguarding the country's unique farming traditions and natural resources.

## References


Adnane, S. (2018). *Women's land ownership in Morocco: Current State & Challenges*. World Bank. Retrieved from OICRF.

Ait-El-Mokhtar, M., Boutasknit, A., Ben-Laouane, R., Anli, M., El Amerany, F., Toubali, S., Lahbouki, S., Wahbi, S., & Meddich, A. (2020). Vulnerability of oasis agriculture to climate change in Morocco (Chap. 4). In *Impacts of climate change on agriculture and aquaculture*.

Akesbi, N. (2023), *New study: "The bet on food sovereignty under the pressures of debt and free trade"*. Siyada Network: for a popular sovereignty over food systems and resources. https://en.siyada.org/akesbi/research-and-publications/new-study-the-bet-on-food-sovereignty-under-the-pressures-of-debt-and-free-trade/.

Altieri, M. A. (2018). *Agroecology: The science of sustainable agriculture*. CRC Press.

Bekkaoui, F., Sadiki, M., & Thami Alami, I. (2024). Contribution of agricultural research for better resilience of Moroccan agriculture. *African and Mediterranean Agricultural Journal - Al Awamia, 143*, 1–8. https://doi.org/10.34874/IMIST.PRSM/afrimed-i143.48153

Benayad, A., Bikri, S., Hindi, Z., Lafram, A., Belfakira, C., Yassif, F.-Z., El Bilali, H., & Aboussaleh, Y. (2024). Transition toward sustainability in the Moroccan food system: Drivers, outcomes, and challenges. *WORLD, 5*, 627–644. https://doi.org/10.3390/world5030032

Bendada, M. et al. (2025). *Effects of soil management on agrobiodiversity in Berkane, NE Morocco*. Soil Sci. Ann.soilsa

Benhammou, H. (2021). *The state-led decline of subsistence farming in Morocco*. Retrieved from War on Want.

Bernis, F., & Fonteneau, A. (2023). *Farmers' variety naming and crop varietal diversity of two major food crops in the high atlas region of Morocco*. Retrieved from IRIS

Chibane, A. (2022). *Moroccan farmers embrace organic farming*. Retrieved from Africanews.

FAO. (n.d.). *Investing in resilience for sustainable food security Moroccan experience*.

FAO. (2011). *The state of food and agriculture 2010–2011: Women in agriculture—Closing the gender gap for development*. Food and Agriculture Organization of the United Nations. Retrieved from FAO Website

FAO. (2019). *The state of the World's biodiversity for food and agriculture*. Food and Agriculture Organization of the United Nations. Retrieved from FAO Website https://www.fao.org

FAO. (2021). *Building resilience for food and nutrition security*. Food and Agriculture Organization of the United Nations. Retrieved from https://www.fao.org

Hakimi, F. (2022). Characterization of the diversity of peri-urban farms in the metropolis of Casablanca in Morocco to facilitate their agroecological transition to more sustainable food systems. *International Journal of Environment, Agriculture and Biotechnology, 7*, 155.

Hamouchene, H., & Minio-Paluello, M. (2022). *Small fields to local forks: Community-supported agriculture for small-scale Agroecological farmers in Southwest Morocco*. Retrieved from Graduate Institute.

High Atlas Foundation (HAF). (2025). *Conserving Traditional Crop Diversity and Wild Medicinal Plants in Morocco*. Retrieved from High Atlas Foundation.

Jabir, B., & Falih, N. (2020). Digital agriculture in Morocco, opportunities and challenges. In 2020 *IEEE 6th international conference on optimization and applications (ICOA)*. : https://doi.org/10.1109/ICOA49421.2020.9094450. https://www.researchgate.net/publication/341477436

Lass, D. (2024). *Community supported agriculture: Research and education for enhanced viability*. Graduate Institute graduateinstitute.

MBLA Association. (2025). *Agrobiodiversity conservation in Morocco's high atlas*. Moroccan Biodiversity & Livelihoods Association mbla association.

MBLA (Moroccan Biodiversity and Livelihoods Association). (2020). *Supporting Amazigh farmers for the conservation of local agrobiodiversity in the Moroccan High Atlas*. Retrieved from MBLA.

Ministère de l'Agriculture, de la Pêche Maritime, du Développement Rural et des Eaux et Forêts. (2020). *Rapport annuel sur l'agriculture marocaine*. MAPMDREF.

Montoya, D., Polk, R., Parra, P., Archbold, G., & Salguero, C. (2024). Beyond industrial agriculture: A case for agroecology adoption in Sefrou, Morocco's semi-arid region. *Moroccan Journal of Agricultural Sciences, 5*(3), 144–151. https://doi.org/10.5281/zenodo.13738279

Moussadek, R. (2025). *Sustainable soil and water Management in Morocco*. ICARDA.

Moussadek, R., El Gharyani, R., & Moutaouakkil, A. (2021). The role of agroecology in enhancing sustainable agriculture: A case study from Morocco. *Sustainability, 13*(14), 7654.

Moussadek, R., El Yahyaoui, M., & Boucetta, A. (2020). The role of agrobiodiversity in sustainable agriculture and food security in Morocco. *Sustainability, 12*(14), 5760.

Ouarghidi, A., & Ben-Meiron, Y. (2018). *Conserving traditional crop diversity and wild medicinal plants in Morocco*. Retrieved from High Atlas Foundation.

Srairi, M.T. (2025). *"Food Sovereignty in Morocco," Moroccan Institute for Policy Food Sovereignty in Morocco—Report*. https://mipa.institute/?p=12723&lang=en

Wezel, A., Bellon, S., Doré, T., & Francis, C. (2014). Agroecology as a science, a movement and a practice: A review. *Agronomy for Sustainable Development, 34*(1), 7–18. https://doi.org/10.1007/s13593-013-0180-7

World Bank. (2015). *Morocco: Gender and development review*. Retrieved from World Bank Website.

World Bank. (2021). *Morocco: Boosting private-sector competitiveness for export success*. Retrieved from World Bank.

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# Chapter 13
# The Unmaking of the Agroecological Transition in Tunisia

**Mustapha Jouili**

**Abstract** This chapter examines the contradictions and limitations of the agroecological transition in Tunisia, highlighting the gap between political discourse and actual practice. While agroecology is increasingly invoked in national strategies and development projects as a sustainable alternative to the dominant productivist agricultural model, it is often reduced to a set of technical practices aimed at improving productivity. This depoliticized, "techno-centric" approach neglects the social, cultural, and political dimensions of agroecology, leaving unchallenged the structural inequalities and export-oriented paradigm that marginalize smallholder and family farms. Drawing on historical analysis, policy review, and field studies, this contribution shows how land concentration, restricted access to resources, and dependence on external inputs—reinforced by neoliberal reforms and donor influence—impede a genuine agroecological transition. It's argued that peasants and small family farms, often already practicing agroecology through traditional, low-input systems, are key actors in building resilience and food sovereignty, yet remain politically and economically sidelined. The chapter concludes that a transformative transition requires re-centring agroecology as a social project rooted in equity, resource sovereignty, and systemic change, rather than as a technical fix within the existing model.

**Keywords** Agricultural policy · Agroecological transition · Family farming · Tunisia

The survey was conducted in 2004 and published by the Ministry of Agriculture in 2006; the FAO published only the summary report. The reference list is to be limited solely to the 2006 MARH publication. There is no need to cite the FAO.

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## 13.1 Introduction

The dominant agricultural productivist model, as a historical driver of economic growth yet also a source of inequality, ecological degradation, and food insecurity, has come under increasing scrutiny over the past few decades. Across the globe, this model—rooted in the logics of industrial intensification, monoculture expansion, and dependence on chemical inputs—has revealed its structural vulnerabilities in the face of climate change, biodiversity loss, and rural dispossession.

The rise of environmental awareness and the growing calls for sustainability have prompted a search for alternative models capable of reconciling productivity with ecological integrity and social justice. In this context, agroecology has emerged not merely as a set of agricultural techniques but as a paradigm for rethinking the relationship between humans, nature, and production systems.

Agroecology has been defined as 'the application of ecological concepts and principles to the design and management of sustainable agroecosystems' (Altieri, 2000). This definition underscores the ecological dimension of agroecology as a science concerned with optimizing interactions among soil, plants, animals, and humans. As a set of agricultural practices, 'agroecology seeks ways to enhance agricultural systems by mimicking natural processes, thus creating beneficial biological interactions and synergies among the components of the agroecosystem. It provides the most favourable soil conditions for plant growth, particularly by managing organic matter and by raising soil biotic activity' (De Schutter, 2010). In this regard, agroecology transforms agricultural production, making it more sustainable, productive, profitable, attractive, and diverse (Wezel et al., 2009; Gonzalez de Molina and Guzman-Casado, 2017). Over time, the understanding of agroecology has expanded to include the transformation of the food system in political, social, and cultural aspects (Anderson et al., 2021). Agroecology is thus increasingly recognized as a practice, scientific discipline, and movement (Wezel et al., 2009). This triple dimension has significant implications: as a science, it challenges the epistemic dominance of industrial agronomy; as a practice, it values traditional and local knowledge systems; and as a movement, it mobilizes social actors—particularly peasants and family farmers—against the hegemonic power of agribusiness and neoliberal development agendas.

Agroecological transition refers to the process of shifting from a system reliant on external inputs and monocultures to a biodiverse system based on agroecological principles (McKay et al., 2025). This transition, in its deeper sense, cannot be reduced to a linear modernization process; it implies a profound transformation of social relations, economic priorities, and governance systems in agriculture. It goes beyond a purely technical approach by explicitly integrating issues of power and politics (Scoones et al., 2015). It involves prioritizing access and control over land and its productive resources, market access, and promoting policies that support agroecological transitions (McKay et al., 2025).

This transition cannot be envisioned without peasants, who are its principal actors. Far from being mere recipients of agricultural policies, peasants embody an

ecological rationality rooted in local knowledge, sustainable practices, and a deep connection to their territories. The "farmer-to-farmer" movement, promoted by La Via Campesina, illustrates this dynamic of horizontal knowledge transmission, based on collective experimentation and the autonomy of rural communities (La Via Campesina, 2015).

In Tunisia, agriculture faces several challenges. It is specifically a matter of addressing the dual challenge of producing more with fewer resources under increasingly restrictive conditions. In this context, ecological intensification can serve as a solution to such a challenge. Balancing the improvement of productivity with the preservation of natural resources and the environment requires adopting a form of intensification that relies more on the biological mechanisms within agro-systems and moves away from the extractive use of natural resources. Thus, in light of the difficulties faced by conventional intensification, particularly in its extensive form, agroecology can provide a global response to the challenges that agriculture must confront (Elloumi, 2018).

In this context, several experiments have been conducted within research and development projects focused on adopting practices that are more environmentally friendly and formulating alternatives to conventional intensification. These alternatives, reflecting the awareness of various stakeholders, aim towards forms of ecological intensification that consider both environmental and productive aspects (De Lattre-Gasquet et al., 2017).

However, despite the proliferation of projects and experiments, the transition to a larger scale remains limited due to various barriers. This includes the absence of an agricultural research policy that allows the application of the concept of agroecology tailored to different Tunisian contexts and identifies the factors that can accelerate its adoption. Agroecology is often reduced to its 'technical aspect' without questioning the dominant agro-exporter model, which favours large farms that are highly intensive and integrated into the international market. This model pushes small, peasant, and family farms—still the backbone of Tunisian agriculture—towards precariousness.

This chapter explores the contradictions and limitations of Tunisia's agroecological transition. Drawing on historical analysis, policy review, and field research, it reveals how land concentration, restricted access to resources, and dependence on imported inputs—exacerbated by neoliberal reforms and donor influence—undermine a truly transformative transition. It highlights the crucial role of peasants and family farms, who often already practice agroecology through traditional, low-input systems, yet remain politically and economically marginalized. Ultimately, the chapter argues for re-politicizing agroecology as a social project rooted in equity, resource sovereignty, and systemic change—rather than a technical fix within the existing agricultural model.

## 13.2 The Multidimensional Crisis of Tunisian Agriculture

Despite some changes in Tunisia's agricultural development model since the early 1960s, several constants remain. These include the secondary role assigned to agriculture and its instrumentalization to support integration into the international division of labour. Similarly, trust has always been placed in large capitalist farms, while most peasants have been viewed as a force of inertia, an obstacle, and a barrier to agricultural modernization. Moreover, the 'modernization of agriculture' at the core of development strategies was mainly seen as a matter of adopting the 'most efficient technologies' to achieve efficiency and profitability.

These characteristics have become more noticeable since the mid-1980s, with the neoliberal shift and the promotion of the agro-export model, which appears to have reached its limits (Jouili & Elloumi, 2023). Since then, the agricultural sector has been experiencing a crisis that grew increasingly serious at the beginning of the 2000s and gradually worsened, peaking in 2007/2008. This is not the first crisis to hit the agricultural sector and rural communities, but it is characterized by its severity and multidimensional and systemic nature.

Economically, we are witnessing a downward trend in the terms of trade for agricultural products. Since the introduction of structural adjustment policies and especially during the post-adjustment period of increased liberalization, agricultural prices have continued to fall relative to input prices. Although producer prices for most agricultural products have risen significantly, this nominal price increase has not been accompanied by a positive trend in real prices. In addition, removing input subsidies and the liberalization of marketing have sometimes caused input prices to rise sharply. Consequently, the trend has been towards worsening price ratios and a more pronounced 'price scissor' phenomenon (Elloumi, 2018; Gana, 2012; Jouili, 2008).

This deterioration could normally have been mitigated by improvements in factor productivity, but as yields reach a ceiling due to worsening production conditions, farmers face declining income. This situation is worsened by the lack of adequate supervision of farmers following the dismantling of public supervisory structures, the absence of market regulation, disorganized supply chains, the weak negotiating power of agricultural producers, and the resulting reduction in their share of value added (Elloumi, 2018).

Furthermore, although 70% of Tunisia's agricultural needs are met by domestic production, the country remains heavily reliant on global markets to meet growing demand, particularly for cereals, vegetable oils, and sugar (ITES, 2023). While Tunisia has become self-sufficient in dairy products, vegetables, and fruit, it still depends greatly on foreign cereal imports, bringing in 50% of cereals for human consumption and 60% for livestock feed (Tanchum, 2022).

On a social level, even if one accepts that poverty has decreased overall, inequalities in income distribution among different social categories and regions remain significant, with agricultural and rural populations still being the most affected by poverty. Rural areas generally exhibit lower development indicators compared to

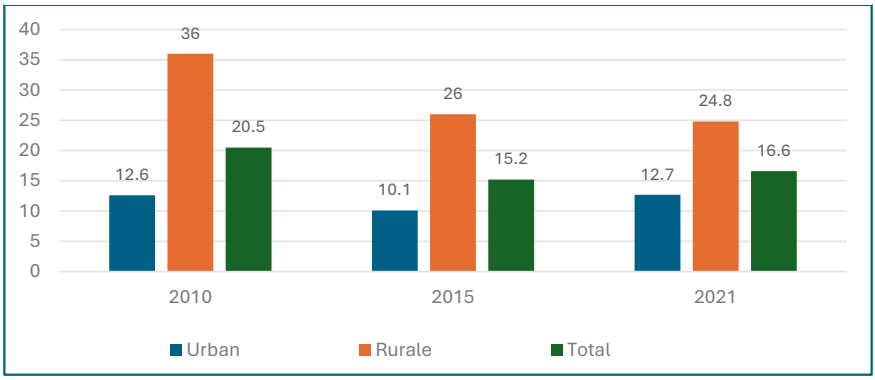



**Fig. 13.1** Poverty rate by area (in %). Source: INS (2023)

urban areas. This is particularly true for poverty and unemployment but also for expenditure levels and, thus, per capita income. The rural population faces greater precariousness in accessing productive resources and certain social services (such as drinking water, basic health, and education) (Bousnina, 2023); however, it cannot be denied that there has been improvement in the living condition indicators of rural populations, which still, in most cases, lag behind those of urban populations.

The 2021 survey on household budgets, consumption, and living conditions (INS, 2023) confirms the situation of rural populations, with a poverty level nearly twice that of the urban population (refer to Fig. 13.1). Thus, the rural population, which makes up only 35% of the total population, accounts for almost 48% of overall poverty, and more than 75% when using the poverty thresholds set by the World Bank (Bousnina, 2023).

By socio-professional category, it is important to note that farmers and farm workers remain among the poorest. In 2021, the poverty rate for agricultural workers was 31.9%, and although they make up only 2.4% of the total population, they account for 4.7% of the poor. Farmers, who constitute 6.6% of the total population had a poverty rate of 22.8%, thereby contributing 9.1% to overall poverty.

The persistent cycle and even consolidation of poverty in rural and agricultural areas have resulted in rising migration rates in recent years, as poor rural residents and peasants move to cities. This trend has caused a devaluation of agricultural work and a decline in interest in farming careers. Evidence of this shift is seen in the ageing population of farmers and the increasing participation of women in the agricultural workforce (Bousnina, 2023; Elloumi, 2018; Jouili, 2008).

The Tunisian agricultural crisis has also gained an environmental aspect. The push for increased agricultural production, based on the Green Revolution model, appears to have reached its limits: first, due to the depletion of the natural resources it relies on, and second, because of the negative externalities it causes on the environment.

Water resources have been systematically mobilized since the early years of independence. In the early 1970s, Tunisia embarked on an agro-export strategy,

which was reinforced by adopting a structural adjustment programme in 1986 that included the state's retreat and the liberalization of access to water resources. Irrigated land has increased significantly, increasing pressure on water resources. The mobilization rate of water resources rose from 59% in 1990 to 98% in 2015 (Elloumi, 2016). Currently, this rate is 117% for surface water and 120% for groundwater (MAPRH, 2023). This may cause deterioration of water quality because of increased salinity in situ or through seawater intrusion (MARHP, 2023: p. 37). Agriculture, the primary user of mobilized water resources, is therefore increasingly facing resource scarcity and growing competition from other sectors, which, although small, is expanding rapidly and is difficult to curb.

Moreover, with its limited agricultural potential, Tunisia is heavily impacted by land degradation, affecting both land structure and biological diversity. Of the country's total area of 16.2 million ha, 10.4 million ha are used for agriculture, including 5 million ha of arable land. According to official reports, desertification and land degradation affect about 75% of the country's territory. Every year, more than 20,000 ha are degraded, with 13,000 ha experiencing nearly irreversible damage, accounting for 0.4% of arable land (OTEDD, 2020). Water erosion stands out as the primary form of land degradation in the country, affecting 3 million ha, of which 1.5 million ha are severely eroded. Furthermore, 46% of crops are grown on land with limited fertility, and 1.1 million ha are cultivated on land susceptible to erosion (ITES, 2017). Besides harsh natural conditions, land degradation is also linked to anthropogenic factors. These include unsuitable agricultural practices, expanding certain crops onto inappropriate land, monoculture, overgrazing, and poor irrigation techniques using poor-quality water (Schütze et al., 2025; Elloumi, 2018). This degradation is further exacerbated by climate change, resulting from rising temperatures, changing rainfall patterns, and extended droughts (Chebbi et al., 2019).

## 13.3 A Reductionist and Technical Conception of Agroecology

Tunisia's awareness of environmental challenges began in the late 1980s, marking an important turning point in the country's relationship with its natural resources. The establishment of the 'Agence Nationale de Protection de l'Environnement' (National Environmental Protection Agency, ANPE) in 1988 reflected a growing recognition of the need to manage environmental degradation through institutional and regulatory mechanisms. The ANPE was entrusted with the development and oversight of national environmental policies, the evaluation of the environmental impact of human activities—including agricultural ones—and the promotion of initiatives aimed at preserving Tunisia's fragile natural resources. Although the agency's mandate does not explicitly focus on agroecology, ANPE is viewed as an indirect player in shaping necessary conditions for Tunisia's agroecological transition. Through its activities in environmental governance, public education, and

regulatory enforcement, the ANPE contributed to creating a conducive framework to the gradual emergence of agroecological practices, even in the absence of direct support for farmers (Dridi, 2024).

A few years later, in 1994, and in alignment with the *National Agenda 21* and the *United Nations Convention to Combat Desertification*, the Tunisian government launched the 'Main Jaune' programme. This initiative aimed to combat land degradation and enhance ecosystem resilience through actions such as rangeland improvement, water and soil conservation, dune fixation, anti-salinization measures, and reforestation and forest regeneration (Ministère de l'Environnement et de l'Aménagement du Territoire, 1999: p. 32). These early efforts illustrated a growing institutional interest in sustainable land management, even though the conceptual framework of agroecology had not yet gained prominence in national discourse.

In recent years, however, agroecology has increasingly entered Tunisia's policy and development vocabulary. Policymakers and institutions—particularly the Ministries of Agriculture and Environment—now frequently invoke the term 'agroecological transition' (MARHP & DGACTA, 2017; Ministère de l'Environnement, 2023). Yet, despite these references, Tunisia still lacks a coherent national policy explicitly dedicated to agroecology. Instead, agroecological principles are often embedded within broader frameworks concerning sustainability, organic farming, or environmental conservation. This fragmented incorporation suggests a limited and primarily instrumental understanding of agroecology—one that reduces it to a set of technical adjustments rather than a transformative paradigm encompassing ecological, social, and political dimensions (Schütze et al., 2025).

Although agroecology is not clearly defined in official documents, it has been integrated across several axes of the *Stratégie Nationale de Transition Écologique* (SNTE), notably Axis 3, which focuses on the 'Sustainable Management of Natural Resources and Ecosystems' (Ministère de l'Environnement, 2023). Within this framework, agroecology is presented as going beyond organic agriculture by incorporating elements of agroforestry and emphasizing food security, social inclusion, and the sustainable management of soil, water, forests, and ecosystems (Ministère de l'Environnement, 2023: p. 36). Similarly, the report *Élaboration de la Stratégie de Conservation des Eaux et des Sols de la Tunisie (CES)* advocates the adoption of agroecological and 'soft' techniques to enhance the success of soil and water conservation measures, particularly in large-scale cereal production areas and on marginal lands (MARHP & DGACTA, 2017: p. 29). The report underlines how agroecological practices—such as improving soil structure and reducing erosive interventions—can mitigate water erosion, increase productivity, and foster local participation in the maintenance of CES infrastructures (MARHP & DGACTA, 2017: p. 26).

Nevertheless, the conceptualization of agroecology within Tunisian public policy remains largely technical and reductionist. It is frequently perceived as a toolbox of environmentally friendly agricultural techniques rather than as a holistic, socio-ecological transformation of agrifood systems. The SNTE highlights practices such as water-saving technologies, irrigation optimization, the use of unconventional water resources, and the reduction of chemical pesticide use (Ministère de

l'Environnement, 2023: pp. 36–37). Likewise, the CES report defines agroecology through practices such as no-till farming, direct seeding, permanent soil cover, crop diversification, and composting (MARHP & DGACTA, 2017: pp. 26, 35). While these measures undeniably contribute to more sustainable agricultural production, their adoption in isolation risks perpetuating the same productivity-driven logic that agroecology fundamentally seeks to transcend.

This technocratic framing extends into the sphere of development projects implemented by national agencies in collaboration with international partners. Between 1999 and 2023, an inventory identified 26 projects or initiatives related to agroecology, supported by organizations such as the FAO, GIZ, IFAD, and ADF (Lestrelin & Jaouadi, 2023). However, these projects group together a wide range of approaches—including conservation agriculture, sustainable agriculture, agroforestry, climate adaptation, organic farming, and permaculture—under the broad label of 'agroecology'. Their activities tend to focus on technical training in composting, mulching, water-efficient irrigation, crop rotation, and the reduction of chemical inputs. Conversely, critical dimensions such as equitable access to natural resources (land, water), local governance, and the valourization of traditional knowledge are marginalized. Moreover, evaluation metrics often prioritize technical and economic performance indicators—such as yield, input reduction, or cultivated area—while neglecting social or political indicators related to empowerment, equity, and participation.

This narrow and instrumental conception of agroecology reveals a profound tension in Tunisia's agricultural development paradigm. By focusing primarily on technical optimization, these initiatives overlook agroecology's transformative potential to reconfigure power relations, market dependencies, and socio-ecological interactions. Farmers are frequently treated as passive beneficiaries expected to adopt externally designed 'best practices', rather than as active co-creators of locally grounded agroecological knowledge. As a result, agroecology risks being depoliticized and co-opted into a technocentric agenda that reinforces, rather than challenges, the dominant agri-industrial model. Overall, in both public policy and development projects, agroecology is reduced to a technical toolkit, disconnected from its political and social dimensions. This 'techno-centric' approach primarily aims to improve agricultural efficiency without questioning the dominant model. This narrow vision of agroecology is, among other things, driven by pressure from donors and multinational agribusinesses.

The role of international donors further reinforces this trend. Donor institutions remain central to the financing of agricultural projects in Tunisia and, consequently, exert significant influence over policy orientations (Requier-Desjardins et al., 2024). Their preference for measurable, short-term outcomes tends to privilege technical solutions over systemic transformation. As a result, agroecology is frequently interpreted in a 'reformist' or 'neoliberal' sense—defined by the pursuit of efficiency gains within existing market frameworks rather than by the redefinition of those frameworks themselves (Walthall et al., 2024). This 'neoliberal agroecology', as Giraldo and Rosset (2023: p. 2) describe, embodies 'the conventional model of industrial agriculture moderated by the selective adoption of agroecological

technologies'. Such a perspective aligns with the FAO's own stance, which presents agroecology as one among several 'promising options' alongside genetically modified organisms (GMOs) and reduced chemical inputs (FAO, 2015). Similarly, the GIZ asserts that 'agroecology does not necessarily exclude certain practices inherited from the Green Revolution' (Jourdane, 2019: p. 129).

Finally, multinational corporations—including seed producers, agrochemical companies, and distributors—continue to hold substantial power within Tunisia's agricultural economy. By dominating input markets and marketing channels, they shape both the material conditions and the ideological framing of agricultural modernization. Their lobbying efforts tend to preserve regulatory environments that safeguard their commercial interests, particularly through the promotion of hybrid and genetically modified seeds. This dynamic further undermines farmers' seed sovereignty and limits the potential for autonomous, locally adapted agroecological innovation—an essential condition for any genuine agroecological transition (Mahjoub and Belghith, 2022).

In sum, Tunisia's current engagement with agroecology reflects a predominantly technical and depoliticized interpretation of the concept. Agroecology is framed as an efficient and environmentally friendly set of tools rather than as a paradigm for social and ecological transformation. While technical progress in areas such as soil conservation, irrigation, and input reduction is commendable, these measures remain insufficient to challenge the structural foundations of industrial agriculture. A truly transformative agroecological transition would require not only ecological innovation but also the reconfiguration of institutional arrangements, market relations, and power dynamics within Tunisia's agrifood system.

## 13.4 Marginalization of Peasants and Family Farms

Agrarian structures in Tunisia reveal a deeply entrenched inequality in land distribution, the roots of which extend back to the colonial period and have been reinforced by post-independence agricultural and economic policies. The modernization-oriented land policy introduced in the mid-1970s and later consolidated through the Structural Adjustment Programme (SAP) implemented in 1986 marked a decisive shift toward liberal economic principles. The overarching goal of these reforms was to enhance the efficiency of land markets and promote the 'optimal allocation of resources'. In practice, however, these policies accelerated the commodification of land, transforming it from a social and cultural resource into a tradable asset governed by market logic. This process has led to a progressive concentration of landownership in the hands of a small number of large landholders, reinforcing class-based inequalities and marginalizing small-scale farmers and peasants (Jouili, 2008; Elloumi, 2018).

Access to agricultural land exposes a clear division between two categories of producers: small-scale peasants, who primarily aim to sustain themselves and feed the nation's population, and large-scale producers, whose main objective is to

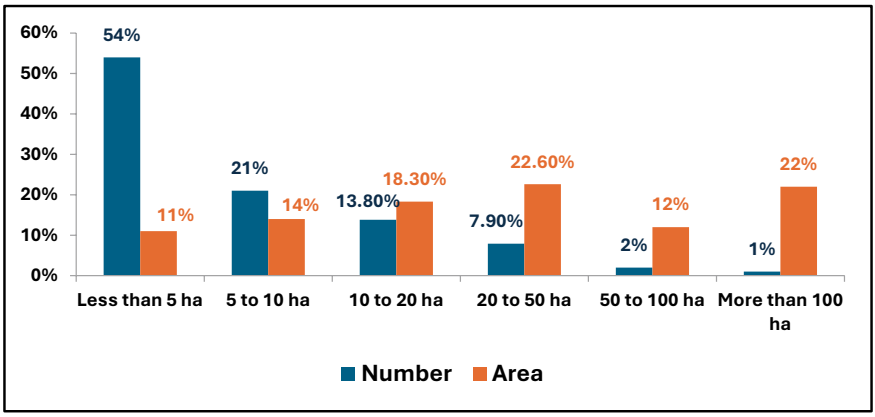



**Fig. 13.2** Agrarian structures in Tunisia. Source: adapted from MARH. 2006 (The latest survey on agricultural structures in Tunisia dates to 2004–2005 and was published in 2006.). Source: adapted from MARH 2006

accumulate wealth and capital. According to the Ministry of Agriculture's surveys, 54% of agricultural producers own less than 5 ha on average and collectively occupy only 11% of the total farmland. In contrast, producers with more than 100 ha make up just 1% of all farmers but control 22% of the total farmland (Fig. 13.2).

Access to agricultural land clearly delineates two categories of producers: on one side, small-scale peasants and family farmers whose primary objective is subsistence and local food provision, and on the other, large-scale producers primarily oriented towards capital accumulation and market profitability. According to data from the Ministry of Agriculture, 54% of Tunisia's agricultural producers own less than 5 ha, collectively controlling only 11% of total farmland. In contrast, the top 1% of producers—those holding more than 100 ha—own approximately 22% of the country's agricultural land. Furthermore, 97% of producers manage less than 50 ha and occupy about 66% of farmland, while the remaining 3% control 34% of it (Fig. 13.2). This concentration demonstrates the persistence of structural dualism in Tunisian agriculture.

Furthermore, family-based and peasant structures continue to play a crucial role in the agricultural sector. Nearly 90% of the agricultural workforce consists of family labour, with wage labour accounting for only 10%. Farms that rely exclusively on family labour represent nearly 78% of all farms and occupy around 45% of the total cultivated area (Jouili et al., 2017). Nevertheless, this diversity and social embeddedness of family farms are rarely considered in public policies and development programs, which tend to apply uniform modernization models regardless of local socio-economic realities.

Field surveys conducted in various regions of Tunisia (Carpentier, 2019; Gasmi et al., 2019; Ben Nasr et al., 2002; Taghouti et al., 2017) demonstrate that peasant and family farms—especially those not primarily oriented towards commercial production—have long adopted agroecological practices such as crop diversification,

organic fertilization, crop rotation, and grazing-based livestock management. Rooted in local knowledge and long-standing traditions, these practices constitute adaptive strategies for coping with climatic variability, as well as economic constraints imposed by the market, input suppliers, agro-industries, and commercial intermediaries. Given the limited capital and liquidity of these farms, agroecological practices serve as an effective means of reducing dependency on external inputs, mitigating production costs, and enhancing overall resilience (Ameur et al., 2020). Agroecological practices offer farmers greater resilience in the face of unfavourable markets and protect their most essential livelihoods. Thus, rather than representing an ideological shift, agroecology in peasant contexts often emerges as a pragmatic response to structural constraints and ecological uncertainty. Such practices have allowed family farms to resist the homogenizing pressures of agro-industrial models (Dugué et al., 2014). Farmers' systematic use of low-input agricultural practices (organic fertilization, intercropping, agroforestry, etc.) aligns with the economic rationality advocated by peasant economy theorists (Van der Ploeg, 2000).

Initiated by small farmers who are reviving and rediscovering ancient practices to increase their production (Rosset et al., 2011), these agroecological practices remain marginal in national agricultural strategies. Several barriers hinder their expansion, including limited technical knowledge dissemination, insufficient training and advisory services adapted to small- and medium-sized farms, and a persistent policy bias favouring industrialized and export-oriented agriculture (Souissi et al., 2023; Gharbi et al., 2025). Policymakers often view small-scale, low-input agricultural systems as archaic remnants of the past rather than as viable models for future sustainability (Goetz et al., 2023). This reductionist view reinforces the perception of peasant agriculture as primitive and unproductive (Daoui & Fatemi, 2014), leading to its exclusion from official plans, which prioritize large-scale organic production for export markets (Chebbi et al., 2019).

The introduction of imported hybrid seeds by the World Food Programme in the 1960s further intensified the marginalization of smallholders (Ajl, 2018). Over the decades, these seeds—produced by multinational agrochemical corporations—have gradually supplanted indigenous varieties adapted to Tunisia's diverse agroecological zones. Since the late 1990s, national legislation, particularly Law No. 99–42 of 10 May 1999 concerning seeds, plants, and plant varieties, has restricted commercial trade to catalogued varieties, effectively privileging hybrid seeds while marginalizing local genetic resources. Consequently, farmers have become increasingly dependent on costly external inputs and seed systems ill-suited to the Tunisian climate, which often require high pesticide and fertilizer use. This dependence undermines farmers' seed sovereignty and limits their ability to conserve, exchange, and improve local varieties—an essential component of agroecological resilience.

Structural inequalities and small farmers' limited access to land and natural resources remain among the most significant constraints to agroecological transition in Tunisia (Carpentier, 2025; Souissi et al., 2024). The neoliberal reforms of the 1980s, especially those concerning irrigation and land tenure, deepened the socioeconomic differentiation between large and small producers leading to marginalization of small farmers and, in some cases, even their disappearance (Jouili et al.,

2017; Gharbi & Elloumi, 2023). As a result, smallholders increasingly rely on informal access mechanisms—such as short-term leasing or sharecropping—which provide little security and encourage overexploitation of fragile natural resources (Gharbi et al., 2022). Insecure tenure, compounded by the lack of official land titles, also prevents smallholders from accessing credit, subsidies, and state development programmes. Gendered dimensions further exacerbate this exclusion, as inheritance laws and patriarchal norms systematically limit women's access to land and decision-making power. These intersecting factors threaten not only the socio-economic viability of small farms but also the ecological sustainability of rural territories. They constitute a significant obstacle to the widespread adoption of agroecological practices, as they threaten the long-term viability that requires secure, long-term access to natural resources.

Although the strategic importance of family farms in achieving a sustainable agroecological transition is increasingly acknowledged (UTAP, 2022), Tunisian agricultural policy has yet to undergo a paradigmatic shift. The long-standing commitment to the productivist model of the Green Revolution—characterized by mechanization, chemical intensification, and export-oriented growth—continues to dominate (Jouili, 2008; Carpentier, 2019; Elloumi, 2018). While the 2016–2020 Agricultural Development Plan marked the first official recognition of 'family and small-scale farming' as a key actor in sustainable development (MARHP, 2015), this rhetorical recognition has not been accompanied by concrete institutional mechanisms or targeted structural reforms. The logic of competitiveness, productivity, and export integration remains the guiding principle of agricultural policy (Gasmi, 2024). The forthcoming 2026–2030 Agricultural Development Plan,[1] as currently outlined, appears to maintain this trajectory—focusing on the modernization of agricultural methods and the expansion of high-value export crops such as olives, dates, and citrus fruits—while remaining silent on fundamental issues such as land redistribution, water access, and financial inclusion for smallholders.

In conclusion, the marginalization of peasants and family farms in Tunisia reflects a deeper structural contradiction at the heart of the national agricultural model. While smallholders embody the principles of resilience, sustainability, and local food security central to agroecology, state policies and market dynamics continue to sideline them in favour of capital-intensive, export-driven agriculture. Without addressing the underlying issues of land inequality, input dependency, and institutional bias, the promise of an agroecological transition will remain largely rhetorical. A genuine transformation requires not only the technical promotion of sustainable practices but also the political empowerment and socio-economic recognition of peasant and family-based farming as the backbone of Tunisia's agrarian future.

[1] Conference by the Chief of Staff of the Minister of Agriculture, Water Resources, and Fisheries, on May 25, 2025. https://www.webdo.tn/fr/actualite/national/tunisie-agriculture-plan-ambitieux-pour2035/222274/#:~:text=Ce%20plan%20s'inscrit%20dans,la%20s%C3%A9curit%C3%A9%20hydrique%20et%20alimentaire.

## 13.5 Conclusion

Agroecology, as a science, practice, and social movement, is recognized worldwide as a sustainable alternative to the productivist agricultural model. In Tunisia, it has been gaining increasing interest for years, particularly in public policy and development projects. The agroecological transition is thus embedded in several development plans and strategies. However, while the discourse of sustainability has gained visibility in policy and development arenas, its implementation has been constrained by a narrow, technocratic interpretation of agroecology prioritizing productivity and efficiency over equity, autonomy, and social transformation.

The Tunisian experience illustrates how agroecology, when stripped of its political and social dimensions, risks being reduced to a managerial toolkit compatible with neoliberal agricultural paradigms. This depoliticization serves to accommodate environmental concerns within existing power structures rather than to challenge them. By promoting agroecology as a set of techniques instead of as a paradigm of transformation, state institutions and international donors preserve the legitimacy of the export-oriented and input-dependent agricultural model.

The failure—or rather the unmaking—of the agroecological transition in Tunisia reflects the enduring hegemony of the Green Revolution model, whose principles continue to shape the country's agricultural governance and development priorities. Despite decades of rhetoric about sustainability, the institutional apparatus of agricultural policy remains dominated by productivist logics. Large-scale, capital-intensive, and export-driven farms continue to receive disproportionate public support, while smallholders—who represent the majority of agricultural producers and embody the potential of agroecological systems—remain marginalized.

This contradiction reveals the limits of what may be termed 'reformist agroecology', a version of agroecology that seeks to make industrial agriculture more environmentally friendly without questioning its underlying power relations or economic dependencies. Such reformism may yield incremental gains—reduced pesticide use, improved water efficiency—but it cannot address the structural roots of ecological degradation and social exclusion. The persistence of land inequality, insecure tenure, and market dependency ensures that most Tunisian farmers remain locked in a cycle of vulnerability, unable to invest in long-term ecological practices or to claim autonomy over their production systems.

Moreover, the agroecological discourse has been selectively appropriated by international donors and institutions as part of a broader 'green modernization' narrative. This process aligns environmental objectives with market mechanisms, emphasizing innovation, competitiveness, and efficiency. By transforming agroecology into a technocratic field of expertise rather than a social movement, this approach neutralizes its emancipatory potential and redefines it as a development tool rather than a pathway to food sovereignty.

The re-politicization of agroecology—placing issues of power, control, and justice at the heart of the debate—is therefore a prerequisite for meaningful change. The Tunisian case demonstrates that the challenge is not merely technical but deeply

political: it concerns the redistribution of authority over the means of production and the democratization of agricultural governance.

## References


Ajl, M. (2018). Post-dependency perspectives on agriculture in Tunisia. *Review of African Political Economy, 45*(156), 300–308. https://www.jstor.org/stable/48540843

Altieri, M. A. (2000). Agroecology: Principles and strategies for designing farming systems. In *Agroecology in Action* (pp. 1–8).

Ameur, F., Amichi, H., & Leauthaud, C. (2020). Agroecology in north African irrigated plains? Mapping promising practices and characterizing farmers' underlying logics. *Regional Environmental Change, 20*, 133. https://doi.org/10.1007/s10113-020-01719-1

Anderson, C. R., Bruil, J., Kiss, C., & Pimbert, P. M. (2021). *Agroecology now! Transformations towards more just and sustainable food systems*. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-61315-0

Ben Nasr, J., Snoussi, C., & Chaar, H. (2002). Family farms sustainability in rural semi-arid areas: Case of Bargou-Siliana in Tunisia. In *Sustainable energy-water-environment nexus in deserts, proceeding of the first international conference on sustainable energy-water-environment nexus in desert climates* (pp. 713–718). https://doi.org/10.1007/978-3-030-76081-6_89

Bousnina, A. (2023). La Tunisie rurale: Les caractéristiques, la fragilité économique et sociale et les principaux facteurs de marginalisation. *Geomaghreb, 19*, 35–54.

Carpentier, I. (2019). Agricultures familiales et nouvelles dynamiques de valorisation dans les oasis anciennes de Tozeur et Gabès (Tunisie): Recompositions socio-territoriales et perspectives de développement. In A. Gana, E. Mesclier, & N. Rebaï (Eds.), *Agricultures familiales et territoires dans les Suds*. Karthala.

Carpentier, I. (2025). Policies and development models for "sustainable" agriculture in Tunisia: An "agroecological transition" in question. *Agroecology and Sustainable Food Systems*, 1–22. https://doi.org/10.1080/21683565.2025.2489428

Chebbi, H. E., Pellissier, J.-P., Khechimi, W., & Rolland, J.-P. (2019). *Rapport de synthèse sur l'agriculture en Tunisie [Rapport de recherche]*. CIHEAM-IAMM.

Daoui, K., & Fatemi, Z. E. A. (2014). Agroforestry systems in Morocco: The case of olive tree and annual crops association in sais region. In M. Behnassi, S. Shahid, & N. Mintz-Habib (Eds.), *Science, policy and politics of modern agricultural systems* (pp. 281–289). Springer. https://doi.org/10.1007/978-94-007-7957-0_19

De Lattre-Gasquet, M., Moreau, C., Elloumi, M., & Ben Becher, L. (2017). Vers un scénario "Des usages agro-écologiques des terres pour une alimentation diversifiée et de qualité et un système alimentaire territorialisé" en Tunisie en 2050. *OCL, 24*(3). https://doi.org/10.1051/ocl/2017025

De Schutter, O. (2010). *Report submitted by the special rapporteur on the right to food to the UN general assembly*. United Nations. https://repository.un.org/handle/11176/288653

Dridi, M. (2024). La Tunisie et le développement durable. *Revue Espace Géographique et Société Marocaine, 88*, 7–29.

Dugué, P., Lejars, C., Ameur, F., Amichi, F., & Braiki, H. (2014). Recompositions des agricultures familiales au Maghreb: Une analyse comparative dans trois situations d'irrigation avec les eaux souterraines. *Revue Tiers Monde, 220*, 99–118.

Elloumi, M. (2016). La gouvernance des eaux souterraines en Tunisie. *IWMI project report* (no. 7). Groundwater governance in the Arab World.

Elloumi, M. (2018). *Tunisie: Agriculture, le développement compromis*. Collection Les Chemins de la dignité. Éditions Nirvana.

FAO. (2015). *Final report for the international symposium on agroecology for food security and nutrition (18–19 September 2014, ROme)*. Food and Agriculture Organization of the United Nations.

Gana, A. (2012). The rural and agricultural roots of the Tunisian revolution: When food security matters. *International Journal of Sociology of Agriculture and Food, 19*(2), 201–213. https://doi.org/10.48416/ijsaf.v19i2.224

Gasmi, H. (2024, September 20). Modernisation agricole en Tunisie: Le revers social et environnemental. *Bar Al Amen*. https://www.researchmedia.org/modernisation-agricole-en-tunisie-le-revers-social-et-environnemental/

Gasmi H., Morardet S., Younsi S., & Burte J. (2019). Évaluation de la durabilité des exploitations agricoles familiales par la méthode IDEA à l'amont du bassin versant Merguellil Kairouan, Tunisie. *Actes de congrès*, *13*. JRSS, Journées de Recherche en Sciences Sociales, 2019/12/12–13, Bordeaux (France) https://www.sfer.asso.fr/source/jrss2019/articles/F22_Gasmi.pdf

Gharbi, I., Aribi, F., Abdelhafidh, H., Ferchichi, N., Lajnef, L., Toukabri, W., & Jaouad, M. (2025). Assessment of the agroecological transition of farms in Central Tunisia using the TAPE framework. *Resources, 14*(5), 81. https://doi.org/10.3390/resources14050081

Gharbi, I., & Elloumi, M. (2023). L'agriculture irriguée en Tunisie: Politiques hydrauliques et politiques de régulation foncière. *Cahiers Agricultures, 32*, 17. https://doi.org/10.1051/cagri/2023010

Gharbi, I., Elloumi, M., & Jamin, J. Y. (2022). Influence of land practices on the sustainability of irrigated farms in Tunisia: An analyze using the IDEA method. *Journal of New Sciences, 88*(3), 4972–4983. https://doi.org/10.55416/sunb.jns01.2204.08803

Giraldo, O. F., & Rosset, P. M. (2023). Emancipatory agroecologies: Social and political principles. *The Journal of Peasant Studies, 50*(3), 820–850. https://doi.org/10.1080/03066150.2022.2120808

Goetz, A., Hussein, H., & Thiel, A. (2023). Polycentric governance and agroecological practices in the MENA region: Insights from Lebanon, Morocco and Tunisia. *International Journal of Water Resources Development.* https://doi.org/10.1080/07900627.2023.2260902

Gonzalez de Molina, M., & Guzman-Casado, G. I. (2017). Agroecology and ecological intensification: A discussion from a metabolic point of view. *Sustainability, 9*(1), 86. https://doi.org/10.3390/su9010086

Institut National de la Statistique. (2023). *Enquête nationale sur le budget, la consommation et le niveau de vie des ménages, 2021* (Vol. A). https://www.ins.tn/sites/default/files-ftp3/files/publication/pdf/Volume%20A_EBCNV_2021.pdf

Institut Tunisien des Études Stratégiques. (2017). *Revue stratégique de la sécurité alimentaire et nutritionnelle en Tunisie*. https://www.admin.ites.tn/api/uploads/files/dec-e6cd15fe476abfd652421281dbe55.pdf

Institut Tunisien des Études Stratégiques. (2023). *La sécurité alimentaire de la Tunisie à l'horizon 2035*. https://www.ites.tn/post/611c0b47a879704850957552.

Jouili, M. (2008). *Ajustement structurel, mondialisation et agriculture familiale en Tunisie*. (Doctoral dissertation,. Université Montpellier 1, France).

Jouili, M., & Elloumi, M. (2023). Extraversion versus développement agricole autocentré : Le cas des pays du Maghreb. *Canadian Journal of Development Studies / Revue canadienne d'études du développement, 44*(3), 410–429. https://doi.org/10.1080/02255189.2022.2092459

Jourdan, R. (2019). *Diagnostic et perspectives de l'agriculture pluviale en Tunisie*. MARHP/DGACTA-GIZ. https://www.giz.de/en/downloads_els/Rapport%20Final%20V4.pdf

Lestrelin, G., & Jaouadi, R. (2023). *Inventory of agroecology-related initiatives in Tunisia (1999–2023)*. International Center for Agricultural Research in the dry areas (ICARDA).

Mahjoub, A., & Belghith, M. M. (2022). *La sécurité et la souveraineté alimentaires et le droit à l'alimentation en Tunisie*. Forum Tunisien pour les Droits Économiques et Sociaux. https://ftdes.net/la-securite-et-la-souverainete-alimentaires-et-le-droit-a-lalimentation-en-tunisie/.

McKay, B. M., Nehring, R., & Catacora-Vargas, G. (2025). The political economy of agroecological transitions: Key analytical dimensions. *The Journal of Peasant Studies, 52*(3), 461–484. https://doi.org/10.1080/03066150.2024.2399138

Ministère de l'Agriculture, des Ressources Hydrauliques et de la Pêche (MARHP). (2015). *Plan de développement du secteur agricole 2016–2020* (in Arabic). https://catalog.agridata.tn/dataset/d194703c-3557-4ba0-9ab4-f143b0fa14c4/resource/7fdf970c-5b0e-4560-8961-91edd1e67fe4/download/plan-de-developpement-2016-2020-1.pdf

Ministère de l'Agriculture, des Ressources Hydrauliques et de la Pêche (MARHP). (2023). *Rapport national sur le secteur de l'eau, année 2021*. Bureau de la planification et des équilibres hydrauliques. https://onagri.home.blog/wp-content/uploads/2022/03/revue_2020_final.pdf

Ministère de l'Agriculture, des Ressources Hydrauliques et de la Pêche, Direction Générale de l'Aménagement et de la Conservation des Terres Agricoles. (2017). *Élaboration de la stratégie de conservation des eaux et des sols de la Tunisie*. https://catalog.agridata.tn/dataset/rapport-final-strategie-de-conservation-des-eaux-et-du-sol/resource/494009b2-03d1-4b2b-9aee-18519956e28a

Ministère de l'Agriculture et des Ressources Hydrauliques (MARH). (2006). *Enquête sur les Structures des Exploitations Agricoles 2004-2005*. Direction Générale des Etudes et du Développement Agricole. http://www.onagri.nat.tn/uploads/divers/enquetes-structures/index.htm

Ministère de l'Environnement. (2023). *Stratégie nationale de transition écologique: Vision, objectifs, actions et mesures*. https://www.environnement.gov.tn/fileadmin/Bibliotheque/SNTE/synthese_SNTE.pdf

Ministère de l'Environnement et de l'Aménagement du Territoire. (1999). *Rapport national sur la mise en œuvre de la convention internationale de lutte contre la désertification*. https://www.unccd.int/sites/default/files/prais-legacy/Tunisia/1999/Tunisia%20-%20ACP%20-%201999%20fre.pdf

Jouili, M., Mkachar, S., & Gusmi, A. (2017). *Étude sur l'agriculture familiale à petite échelle au Proche-Orient et Afrique du Nord*. Pays focus. FAO/CIRAD/IAMM. https://openknowledge.fao.org/handle/20.500.14283/i6660fr

Observatoire Tunisien de l'Environnement et du Développement Durable. (2020). *Rapport national sur l'état de l'environnement-2019* [In Arabic]. https://www.environnement.gov.tn/fileadmin/Bibliotheque/SNTE/rnee_2019_ar.pdf

Requier-Desjardins, M., Boughamoura, O., & Lemaître-Curri, E. (2024). Characterizing agroecology in North Africa: A review of 88 sustainable agriculture projects. *Land, 13*, 1457. https://doi.org/10.3390/land13091457

Rosset, P. M., Machín Sosa, B., Roque Jaime, A. M., & Ávila Lozano, D. R. (2011). The campesino-to-campesino agroecology movement of ANAP in Cuba: Social process methodology in the construction of sustainable peasant agriculture and food sovereignty. *The Journal of Peasant Studies, 38*(1), 161–191. https://doi.org/10.1080/03066150.2010.538584

Schütze, N., Thiel, A., Buhrow, A., Fouzai, A., & Götz, A. (2025). Soil governance in Tunisia: Analyzing the potentials for agroecology transformations. *Agroecology and Sustainable Food Systems*. https://doi.org/10.1080/21683565.2025.2456912

Scoones, I., Leach, M., & Newell, P. (2015). *The politics of green transformations*. Routledge. https://doi.org/10.4324/9781315747378

Souissi, A., Dhehibi, B., Frija, A., Alary, V., Mejri, R., Zlaoui, Z., & Dhraief, M. Z. (2023). Contraintes et défis de la transition agroécologique comme perçus par les agriculteurs en Tunisie. In *INRGREF International Scientific Days 2023: Sustainable management of ecosystems for agroecological transition and food security*. https://agritrop.cirad.fr/608721/1/2023_contraintes%20et%20defis%20de%20la%20TAE_Asma%20et%20al%202023.pdf

Souissi, A., Dhehibi, B., Oumer, A., Mejri, R., Frija, A., Zlaoui, M., & Dhraief, M. Z. (2024). Linking farmers' perceptions and management decision toward sustainable agroecological transition: Evidence from rural Tunisia. *Frontiers in Nutrition, 11*, 1389007. https://doi.org/10.3389/fnut.2024.1389007

Taghouti, I., Elloumi, M., Derbali, C., & Albouchi, L. (2017). Évaluation de la durabilité et des stratégies d'adaptation des exploitations agricoles familiales: Cas de la zone d'El Amaiem-El Fahs-Zaghouan. *Annales de l'INRAT, 90*, 223–241. http://www.annalesinrat.tn/issues/currentIssue/Volume%2090/Volume%2090%20Article%2017.pdf

Tanchum, M. (2022). *The fragile state of food security in the Maghreb: Implication of the 2021 cereal grains crisis in Tunisia, Algeria, and Morocco*. Middle East Institute. https://www.mei.edu/sites/default/files/2021-11/The%20Fragile%20State%20of%20Food%20Security%20in%20the%20Maghreb-%20%20Implication%20of%20the%202021%20Cereal%20Grains%20Crisis%20in%20Tunisia%2C%20Algeria%2C%20and%20Morocco%20.pdf

Union Tunisienne de l'Agriculture et de la Pêche. (2022). *Plan d'action national de la Tunisie 2022–2030, pour une agriculture familiale viable et mieux intégrée dans des systèmes alimentaires durables*. UTAP–FAO. https://faolex.fao.org/docs/pdf/tun221683.pdf

Van der Ploeg, J. D. (2000). Revitalizing agriculture: Farming economically as starting ground for rural development. *Sociologia Ruralis, 40*(4), 497–511. https://doi.org/10.1111/1467-9523.00163

Walthall, B., Vicente-Vicente, J. L., Jonathan, F., Piorr, A., & Lopez-García, D. (2024). Complementing or co-opting? Applying an integrative framework to assess the transformative capacity of approaches that make use of the term agroecology. *Environmental Science & Policy, 156*. https://doi.org/10.1016/j.envsci.2024.103748

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., & David, C. (2009). Agroecology as a science, a movement and a practice: A review. *Agronomy for Sustainable Development, 29*(4), 503–515. https://doi.org/10.1051/agro:20080256

Institut Tunisien des Études Stratégiques. (2017). Revue stratégique de la sécurité alimentaire et nutritionnelle en Tunisie..https://www.admin.ites.tn/api/uploads/files/dece6cd15fe476abfd652421281dbe55.pdf

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# Chapter 14
# Agrobiodiversity Renewed by Visionary Farmers: The Role of Underutilized Crops in Mobilizing Local Knowledge, Activating Alternative Food Networks, and Building Resilience

**Chiara Flora Bassignana and Paola Migliorini**

**Abstract** This research analyses several case studies of underutilized crop farms across Europe, including bere barley grown in Orkney, Scotland; local beans' landraces in Peloponneso, Greece; local wheat landraces in Piedmont, Italy; and local leafy greens in Azore Islands, Portugal. Local neglected and underutilized crops are landraces, varieties, or cultivars that currently have limited use in a given geographic, social, and economic context. However, they play a fundamental role in the local biocultural context and hold great promise for diversifying agricultural systems, enhancing diets, creating resilient agroecosystems, and creating economically viable dynamic value chains. Our research, part of the Horizon 2020 Project RADIANT, Realizing Dynamic Value Chains for Underutilised Crops, highlights how farmers have successfully valourized underutilized crops. They achieved this by collecting and multiplying these crops, rebuilding or reinventing alternative value chains, and building narratives that convey the great potential of such crops. The revival of these underutilized crops in these contexts has played a fundamental role for farmers and the surrounding communities in mobilizing local knowledge, building networks, diversifying economic streams, and strengthening agroecological pathways and agricultural resilience. Underutilized crops play a pivotal role in advancing agroecological transitions by supporting the systematic changes needed to create more sustainable, resilient, and equitable food systems.

**Keywords** Forgotten crops · Agroecological transitions · Local crops

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## 14.1 Introduction

The loss of agrobiodiversity represents one of the most pressing challenges in contemporary agricultural and food systems (Elouafi, 2024). Agrobiodiversity encompasses the variety and variability of plant, animal, and microbial genetic resources that sustain ecosystems and underpin food production (Jenkins et al., 2023). However, the homogenization of agriculture driven by industrial practices, market demands, and globalized food supply chains has led to a dramatic decline in this diversity (Kennedy et al., 2022; Delbaere et al., 2014). Key threats include monoculture farming, the prioritization of high-yield crops, and the loss of traditional agricultural practices (Jones at al. 2021). This erosion of agrobiodiversity not only diminishes the resilience of farming systems to environmental changes but also threatens cultural practices and related knowledge closely tied to local agroecosystems (Canella et al., 2022; Rasul et al., 2022; Kennedy et al., 2022; Bayudan et al., 2024).

Agroecology offers a comprehensive approach that seeks to holistically address the loss of agrobiodiversity. As a science, a set of practices, and a social movement, agroecology integrates ecological principles into agricultural systems while emphasizing the value of local knowledge and participatory approaches (HLPE, 2019). By fostering biodiversity, promoting circular resource use, and strengthening local food sovereignty, it provides a comprehensive framework to counteract the decline in agrobiodiversity and guide the transition towards sustainable and resilient food systems. In this context, underutilized crops can play a critical role, aligning with agroecological principles to address the challenges faced in agriculture and food systems (Migliorini et al., 2018; Fernandez Gonzales et al., 2021).

Preservation and revitalization of underutilized crops emerge as an essential strategy to counteract the decline in agrobiodiversity (Jenkins et al., 2023; Mudau et al., 2022). Underutilized crops are defined as landraces, varieties, or cultivars with limited current use in specific geographic, social, or economic contexts (Padulosi & Hoeschle-Zeledon, 2004). Despite their marginalization in mainstream agriculture, these crops hold significant potential for diversifying agricultural systems, enhancing food security, and enriching diets with culturally and nutritionally valuable foods (Mabhaudhi et al., 2022; Hunter et al., 2019; Nicita et al., 2024).

The underutilized status of these crops often results from historical neglect, the dominance of global food systems, or shifts in societal preferences. Yet, their qualities, such as adaptability to marginal environments, resistance to pests and diseases, nutritional properties, and suitability for smallholder farming systems, make them pivotal in addressing contemporary challenges, including climate change, resource scarcity, and the need for equitable food systems (Jenkins et al., 2023; Rovoredo-Giha et al. 2022; Mudau et al., 2022). Underutilized crops often embody centuries of local knowledge and adaptation, making them integral to the biocultural heritage of communities and key assets for developing sustainable and resilient agricultural systems (Aworh, 2018).

It is essential to distinguish underutilized crops from minor crops, as these terms are sometimes used interchangeably. In the European Union, a minor crop is defined as one that is cultivated on an area of <10,000 but >600 ha. Additionally, the production of a minor crop is lower than 200,000 t per year, but its daily dietary intake contribution is <7.5 but >1.5 g/day (Pannacci et al., 2017). Underutilized crops are often considered a subcategory of minor crops; however, there is a key distinction between the two: minor crops generally refer to neglected crops that have the potential within food systems, whereas underutilized crops encompass not only these crops but also landraces and varieties within existing crops. These varieties may include neglected types of major crops, yet they exhibit significant potential due to their adaptability to local conditions or specific nutritional characteristics. For example, although corn and wheat are categorized as major crops, certain neglected local varieties of these crops adapted to specific agroecosystems can be classified as underutilized crops.

The preservation and renewal of underutilized crops depend on diverse processes and actors. Farmers, particularly smallholders, play a vital role in stewarding these crops, often acting as custodians of local agrobiodiversity (de Avila et al., 2025). Through practices such as seed saving, on-farm conservation, and selective breeding, these farmers help maintain and enhance the genetic diversity of underutilized crops (Barcaccia et al., 2016). Their efforts are complemented by the work of researchers, grassroots organizations, and policymakers who advocate for the recognition and support of these crops.

This research aims to explore the adoption and impacts of underutilized crops through the lens of visionary farmers across diverse European contexts. Specifically, the study aims to (i) investigate why and how farmers are adopting underutilized crops, examining the motivations, values, and contextual factors that drive their adoption, as well as the practices, strategies, and innovations employed to cultivate, preserve, and promote underutilized crops within their local systems; (ii) inquire the social, economic, and ecological impacts of adopting underutilized crops perceived by the farmers, on their activity, their communities, and the broader food system; and (iii) assess the role of underutilized crops in mobilizing local knowledge, activating alternative food networks, and building resilience, focusing on how these crops catalyse community engagement and contribute to agroecological pathways. By addressing these objectives, the study highlights the transformative potential of underutilized crops in fostering sustainable agroecological transitions.

## 14.2 Material and Methods

This research was conducted as part of the European Horizon 2020 project 'RADIANT— Realizing Dynamic Value Chains for Underutilised Crops'.[1] RADIANT aims to promote agrobiodiversity by enhancing the value of underutilized crops and supporting their adoption. The project focuses on testing sustainable agricultural practices and fostering their integration into profitable value chains through social, political, and governance innovations. Spanning 4 years, the project includes 20 pilot sites (known as AURORA farms) across Europe. These sites represent diverse pedo-climatic regions and agroecosystems. These pilots serve as living laboratories where best practices are tested and demonstrated. The fieldwork was conducted from May 2022 to November 2023 in six selected case studies (refer to Fig. 14.1).

The case studies were selected from the 20 pilot farms (AURORA farms) in the RADIANT project. These farms were chosen to represent three different climatic zones in Europe: Mediterranean, Atlantic, and Continental. Moreover, the selection was based on the underutilized crops cultivated at these farms, ensuring a diverse representation of agroecosystem, agricultural practices, and food chains.

In total, 15 interviews were conducted across the six case studies. The interviewees were 11 farmers, 2 retailers, and 3 researchers who work closely with the farmers, specifically on the underutilized crops adopted at the farms (see Table 14.1). One interviewee in Orkney serves as both a farmer and a researcher, and he was interviewed regarding both roles.

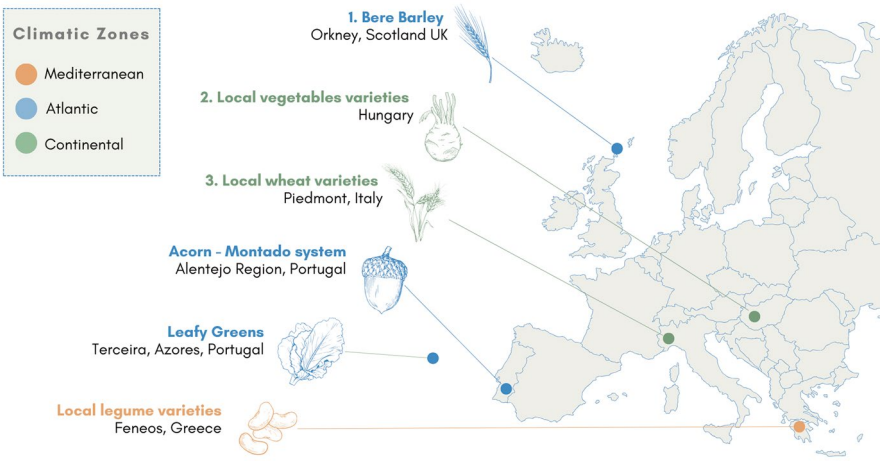



**Fig. 14.1** The six case studies included in this research, with the relative information about: underutilized crops adopted, geographical positions, and climatic zones - Figure created by the authors

[1] https://www.radiantproject.eu/.

**Table 14.1** Farm size, the underutilized crops adopted, and the interviewees for each case study

| Case study | Location | Farm size | UCs | Farming system | Interviewees | Role | Age | Gender |
|---|---|---|---|---|---|---|---|---|
| 1 | Orkney, Scotland, United Kingdom | 20 ha average farm size | Bere barley | Cereal and forage crop rotation system and pastures | A | Researcher and farmer | 40 | Male |
| | | | | | B | Researcher | 60 | Male |
| | | | | | C | Farmer | 65 | Male |
| | | | | | D | Farmer | 50 | Female |
| | | | | | E | Farmer | 70 | Male |
| 2 | Hungary | 1500 $m^2$ | Local varieties of vegetables | Vegetable garden | F | Farmer | 38 | Female |
| 3 | Piedmont region, Italy | 10 ha | Local wheat and other grain varieties | Cereal and forage crop rotation system | G | Farmer, owner of the mill, shop, and laboratory | 61 | Male |
| | | | | | H | Farmer, owner of the mill, shop, and laboratory | 62 | Male |
| 4 | Alentejo region, Portugal | 600 ha | Acorn - Montado system | Agroforestry system | I | Farmer | 50 | Male |
| | | | | | J | Employee working on the conservation and educational projects | 40 | Female |
| 5 | Terceira Azores Islands | 750 $m^2$ | Leafy greens - 100 species | Bio-intensive horticultural | K | Farm owner and farmer | 60 | Male |
| 6 | Feneos, Greece | 10 ha average farm size | Local leguminous crops | Cropping system with legumes and cereal in rotation | L | Retailer | 45 | Male |
| | | | | | M | Retailer | 40 | Female |
| | | | | | N | Farmer | 60 | Male |
| | | | | | O | Farmer | 65 | Male |

In each farm, several days of fieldwork were conducted, during which farmers were interviewed multiple times. In Orkney, multiple farms cultivating bere barley were included, allowing for a comparison of different approaches and perspectives among the farmers.

The interviews were structured into three phases. The first phase focused on the interviewees' life histories, their motivations for starting farming, and their reasons for incorporating underutilized crops into their agroecosystems. The second phase explored the specific practices they adopted and the perceived benefits and challenges of using these underutilized crops. The third and final phase examined the environmental, economic, and social impacts as perceived by the interviewees, providing a holistic understanding of the role of underutilized crops on their farms.

Throughout the field study, the ethical guidelines adopted by the American Anthropological Association (2012) were followed. Interviews were recorded and transcribed, transcripts were qualitatively analysed through thematic content analysis, and codes, concepts, and categories were generated (Guest et al., 2011). We derived descriptive statistics from the interviewees' replies to specific questions in the semi-structured interviews.

## 14.3 Results and Discussion

This section is structured to align with the study's objectives and provides a comprehensive analysis of the findings across four interconnected sections. First, it examines the motivations and transformative practices of farmers who adopt underutilized crops, emphasizing their visionary capacity to redesign agricultural systems. Next, it analyses the role of underutilized crops in mobilizing local knowledge, illustrating how these crops reconnect farmers with traditional practices while integrating modern innovations. The third section delves into the economic and environmental resilience that underutilized crops foster, exploring their contribution to diversified revenue streams and ecological sustainability. Finally, the discussion concludes with an exploration of how underutilized crops support agroecological transitions, aligning with key principles and levels of transformation to create more sustainable and equitable food systems.

### *14.3.1 Visionary Farmers: Motivations and Transformative Practices*

Farmers who adopt underutilized crops are driven by a rich tapestry of motivations that intersect ecological, cultural, and practical considerations. These motivations, shaped by the environmental conditions, cultural heritage, and socio-economic

realities of their regions, serve as the foundation for their transformative agricultural practices.

The farms included in this study vary significantly in size, geographical location, climatic conditions, underutilized crops adopted, levels of agrobiodiversity in the field, and agricultural and economic practices employed.

A diverse array of strategies and approaches was selected to highlight how, in different contexts, underutilized crops contribute to farm resilience and how their adoption triggers or supports specific practices and systems. In certain case studies, the adoption of underutilized crops was closely linked to the aim of diversifying agroecosystems and the resulting farm products. For instance, the case study (5) in the Azores features over 100 varieties of leafy greens cultivated to enhance crop diversity, while the Hungarian farm (2) prioritizes providing its clients with a broader diversity of vegetables, flavours, and nutrients throughout the year. In other cases, the motivation for adopting underutilized crops was more about cultivating resilient varieties that are highly adapted to local pedoclimatic conditions and are deeply connected to the local biocultural heritage. For example, the case study (3) in Piedmont, Italy, focuses on cultivating local wheat and grain varieties for flour production, while the bere barley farms in Orkney (1) aim to reestablish its cultivation as it is well-suited to the island's challenging conditions of strong winds, high salinity, and thin soils. Similarly, farmers in Feneos, Greece (6), prioritize the cultivation of local bean varieties as part of their agricultural and cultural heritage.

The main motivations mentioned by interviewees for adopting underutilized crops have been categorized into four categories: cultural preservation and innovation, environmental sustainability, diets and food security, and sustainable economies and food chains, as illustrated in Fig. 14.2.

One prominent motivation is ecological restoration and sustainability. At the montado farm (4) in Portugal, the farmers strive to rejuvenate the montado system, a traditional agroforestry landscape that has suffered degradation from overgrazing and exploitative practices over the last few decades. By reintroducing rotational grazing, increasing the diversity of tree species, and utilizing native livestock breeds, they aim to restore the ecosystem's balance. Their innovative use of acorns, which have traditionally been overlooked, exemplifies how ecological awareness intertwines with the revival of lost practices. The interviewee I explained, 'The sweet acorn is a gift from nature. It's gluten-free, full of antioxidants, and provides a balanced source of protein and energy. We're just beginning to tap into its potential'. Their work highlights the integration of ecological principles into product development, transforming a historically sustainable landscape into a modern system of innovation that bridges ecosystem conservation and food chain development.

Another significant driver is the desire to enhance food and nutritional security through diversified systems. In the Azores, the farmer K has developed a highly diversified leafy greens production system. Initially focusing on a few varieties, his efforts expanded to integrate dozens of local and non-local but low-input varieties, maximizing nutrient cycling and productivity. His approach included several composting techniques, crop rotations, and seed-saving practices. He emphasizes, 'My idea is to occupy every square centimetre of my farm with a plant that is edible,

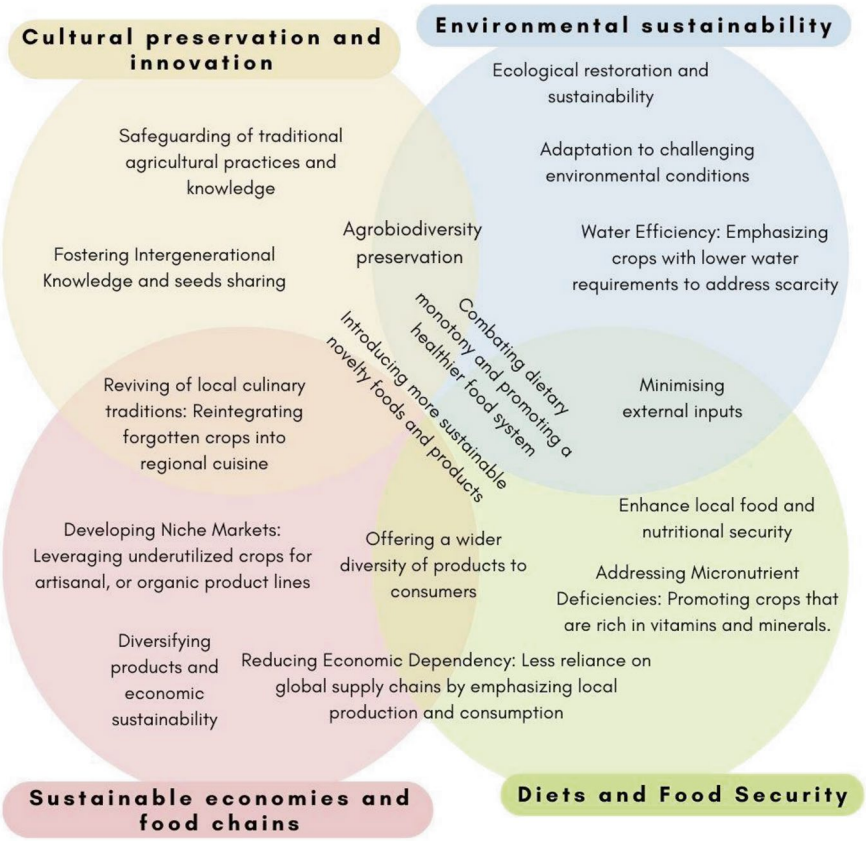



**Fig. 14.2** Motivations reported by the interviewees for adopting underutilized crops in their farms clustered in four main categories - figure created by the authors

commercial, or desired by someone. This way, I produce more with less'. This vision is rooted in a commitment to combating dietary monotony and promoting a healthier food system for his local community.

Additionally, agrobiodiversity preservation and safeguarding traditional agricultural practices also emerge as strong motivations in this context. In Piedmont, Italy, farm 3 focuses on cultivating local grains, emphasizing the need for seeds that are both regionally adapted and culturally significant. This practice not only maintains the genetic diversity of traditional varieties but also supports the continuity of historical farming knowledge in a modern context. Their artisanal approach to grain production, which includes stone milling and wood-fired baking, exemplifies the interplay between tradition and innovation.

Economic sustainability and creating viable markets for traditional crops play a pivotal role in the adoption of underutilized crops. Farmers associated with the case study 6 in Greece cultivate local varieties of legumes of the Feneos Valley. Their

efforts to build markets for these crops help ensure the continuation of legume farming traditions while addressing contemporary economic challenges. Similarly, farm 2 in Hungary incorporates locally adapted varieties to provide flavourful, nutrient-rich produce, aligning her motivations with both community needs and agricultural resilience.

Adapting to challenging environmental conditions further underscores the adoption of underutilized crops. Farmers cultivating bere barley in Orkney, Scotland, are guided by the crop's unique resilience to the island's extreme pedo-climatic conditions. This ancient barley thrives under thin soils, strong winds, and salty air, making it an essential crop for sustaining local agriculture. The preservation of bere barley, led by a small number of farmers, reflects the crop's adaptability and deep-rooted cultural and environmental significance in Orkney. The bere barley farmer C reflects, 'My family has grown bere barley for generations. It's more than a crop, it's part of our heritage'.

These motivations are intertwined with the visionary capacity of farmers to reimagine their agricultural systems. Across these diverse contexts, the power of these visions emerges as a unifying theme. Farmers who adopt underutilized crops demonstrate creativity and determination, designing agricultural systems that integrate ecological principles, support cultural heritage, and address contemporary challenges. These visions are not static but evolve in response to new knowledge, market opportunities, and environmental conditions, showcasing the transformative potential of underutilized crops in reimagining sustainable agriculture.

### *14.3.2 The Role of Underutilized Crops in Mobilizing Local Knowledge*

The adoption of underutilized crops has been an effective mechanism for mobilizing and revitalizing local knowledge systems. These crops often embody centuries of adaptation and cultural heritage, reconnecting farmers and communities with traditional practices while integrating contemporary ecological and scientific insights. In this context, the revival and conservation of local landraces plays a critical role, particularly in Europe, where many landraces have already disappeared or cannot be identified properly, hindering their potential use. Landraces not only serve as a reservoir of potentially valuable traits but also represent an irreplaceable bank of highly co-adapted genotypes, essential for sustaining biodiversity and agricultural resilience (Barcaccia et al., 2016). Moreover, the preservation of local landraces, varieties, and crops ensures the continuity of a rich heritage of knowledge and practices developed over centuries through the co-evolution of local communities and these crops (Bayudan et al., 2024).

In the case study 6, in Greece, the cultivation of legumes such as Gigantes Feneou and Fava Feneou exemplifies the preservation and evolution of local agricultural knowledge. Farmers in the Feneos Valley employ techniques passed down through

generations, including hand-sowing, drying, and cleaning, to maintain seed purity and the unique characteristics of their crops. These practices are cultural artefacts that reflect the intimate relationship between local communities and their environment. By saving seeds for the next planting season, farmers ensure the continuity of these varieties while adapting them to changing climatic conditions. This connection to their heritage strengthens community identity and fosters a sense of pride among farmers.

In Orkney, Scotland, bere barley cultivation showcases the synergy between traditional and scientific knowledge. This ancient landrace, adapted to the harsh pedoclimatic conditions of the islands, had nearly disappeared due to the dominance of high-input commercial varieties. However, local farmers, with support from the Agronomy Institute of the University of the Highlands and Islands, have revived bere barley through participatory breeding programmes and field trials. These efforts combine the experiential knowledge of farmers, such as crop rotation schemes and soil management techniques, with scientific research focused on climate resilience and nutritional profiling. The bere barley farmer C, deeply involved in this process, remarked: 'Bere barley has always been part of Orkney's identity. Working with researchers allows us to preserve this heritage while exploring its future potential'.

Similarly, at the leafy green farm (5) in the Azores, the farmer's (K) self-taught farming methods illustrate how individual innovation can intersect with local knowledge systems. Farmer K has developed a closed-loop farming system that emphasizes the microbiology of the soil, a principle he learned through experimentation and observation. He integrates several composting techniques such as compost tea and compost processed by livestock (chickens, ducks, and pigs) combined with a highly organized system of crop rotation and intercropping and natural pest management to maintain soil health and optimize plant growth. The case study (5) farm features numerous local species of leafy greens, many of which possess unique and distinctive traits, all of which he discovered across the island by engaging with elders. He combines local leafy green species with novel crops that are either resilient and require minimal inputs or possess exceptional nutritional qualities. His approach also includes exotic underutilized crops, which, although not native, offer opportunities to diversify farming systems. These crops can provide distinct advantages for small-scale farmers, such as creating niche market opportunities through their uniqueness. Furthermore, they contribute to improved human nutrition and a sense of well-being derived from the experience and satisfaction of cultivating them (Kell et al., 2018).

This holistic approach serves not only as a practical farming strategy but also as a platform for education. He actively shares his methods with local farmers and community members, emphasizing the importance of respecting soil ecosystems. 'If everyone on this planet respected the microbiology of the soil, plants would flourish for generations to come', he asserts, highlighting the broader implications of his practices.

Case study 4 in Portugal offers another perspective on mobilizing local knowledge. The farm's revival of the montado system involves reintroducing agroforestry

practices that had been largely abandoned. These practices include rotational grazing, diversifying the forest with several fruit tree varieties, adopting several local breeds of livestock, and using oak trees for their ecological services, such as water regulation and soil stabilization. The farm has also rediscovered the nutritional and economic potential of acorns, a staple food in historical diets. Interviewee J, one of the farm's managers, explained, 'Acorns are a gift from the ecosystem, not just for livestock but for humans too. They're gluten-free, rich in antioxidants, and incredibly versatile'. This rediscovery has transformed acorns into a symbol of the *montado*'s resilience, bridging historical practices with innovative product development.

In each of these examples, the mobilization of local knowledge serves as both a foundation and a catalyst for the successful adoption of underutilized crops. Farmers draw on traditional practices, adapt them to meet contemporary needs, and share their innovations with others. This creates a feedback loop that enriches both the farming community and the broader society. This process not only sustains agrobiodiversity but also reinforces the cultural and ecological connections underpinning resilient food systems.

Through their visionary capacity, these farmers reimagine agricultural systems by integrating ecological stewardship with economic and social innovation in their work.

### *14.3.3 Role in Building Economic and Environmental Resilience*

Integrating underutilized crops into farming systems significantly enhances both economic viability and environmental sustainability. These crops diversify agricultural systems by introducing genetic, functional, and market variety. This diversification helps mitigate risks associated with climate variability, pests, and market fluctuations. The inclusion of underutilized crops not only strengthens ecosystems but also creates diversified economic streams, offering resilience at multiple levels.

At farm 4, the *montado* agroforestry system highlights the potential of underutilized crops to bolster environmental resilience by integrating natural irrigation systems and biodiversity enhancement into a sustainable model. The trees' ability to regulate water and provide shelter ensures long-term ecological stability while enhancing the productivity of the agroecosystem. Additionally, the preservation and regeneration of traditional landscapes, such as the *montado*, alongside the creation of new agroforestry areas, significantly diversify the landscapes. This diversification enhances landscape biodiversity, which can help farms better cope with stress and disturbances, thereby maintaining resilience (Nicita et al., 2024).

In the Azores, farm 5 practices reflect the ecological benefits of integrating underutilized crops. By cultivating over 100 plant species within a closed-loop system, farmer K minimizes waste, enhances soil fertility, and reduces dependency on

chemical inputs. His composting techniques enrich the soil, supporting healthy plant growth.

The leafy greens greenhouse plots are densely intercropped and surrounded by agroforestry hedgerows that contain a diverse array of arboreal plants. Such highly diversified agroecosystems offer numerous advantages, including herbivore suppression, allelopathic effects, and reduced crop damage, as studies have shown that diversified cropping systems experience significantly less damage compared to monocultures or systems with fewer associated plant species (Letourneau et al., 2015; Isbell et al., 2017). This holistic approach not only ensures high productivity on a small plot but also promotes biodiversity (Tamburini et al. 2020). 'We can produce more with less', Interviewee K explains, emphasizing the efficiency of his system. The ecological benefits extend beyond the farm, as his promotion of diverse and innovative foods, such as smoothies rich in vitamins, helps counteract the monoculture found in both fields and plates.

In Orkney, Scotland, bere barley thrives in challenging conditions—thin soils, strong winds, and saline air—while requiring minimal chemical inputs. Its low-input characteristics help reduce dependence on fertilizers and pesticides. Bere barley has diverse applications, including traditional foods like bannocks and contemporary uses in whisky and beer, which expands its economic potential. The Agronomy Institute's collaboration with local farmers has also explored its role in enhancing soil health and carbon sequestration. Interviewee C, a local farmer, emphasizes its dual importance, stating 'Bere barley sustains our heritage and supports a farming system aligned with the land'.

Integrating underutilized crops into farming systems strengthens economic resilience by creating diversified revenue streams and reducing reliance on volatile markets. At farm 3, in Italy, the cultivation of ancient grains such as einkorn and spelt helps preserve traditional practices while meeting consumer demand for artisanal and organic products. The farm's closed-loop grain economy, which encompasses stone milling and wood-fired baking, supports local food sovereignty and commands premium prices. Their flagship product, Pan Barbarià, made from wheat and rye intercropped in the field, embodies the cultural and economic value of underutilized crops, connecting consumers to the local agricultural heritage.

Hungary's farm (2) highlights the economic benefits of underutilized crops by offering diverse, flavourful produce that attracts consumers seeking unique, high-quality options. This approach not only ensures consistent income but also builds strong connections between farmers and their communities. Underutilized crops contribute significantly to enhancing ecosystem services, such as improving soil health, reducing erosion, and fostering biodiversity (Isbell et al., 2017; Letourneau et al., 2015). Their low input requirements and adaptability to diverse conditions make them integral to the sustainability of agricultural systems. As interviewee F observed, 'Enhancing diversity establishes a more resilient farming system, which is particularly important in the changing climatic conditions'.

The integration of underutilized crops also contributes to social resilience. Many of these farms serve as educational hubs, reconnecting communities with their agricultural heritage and promoting sustainable practices. At farm 4, educational

programmes highlight the ecological and cultural significance of the montado system, while farm 5 engages local chefs and consumers to explore the culinary potential of underutilized crops. These initiatives foster a deeper appreciation for biodiversity and encourage community involvement in sustainable food systems.

In summary, underutilized crops play a significant role to resilience by enhancing environmental stability, economic sustainability, and social cohesion. Their adaptability to local conditions, lower input requirements, and diverse applications make them essential components of sustainable agricultural systems. By adopting these crops, farmers can reduce vulnerability to environmental and economic challenges while fostering deeper connections between communities, cultures, and ecosystems. These efforts collectively build a food system that prioritizes diversity, equity, and long-term viability.

#### 14.3.3.1 Role of Underutilized Crops in Agroecological Transitions

Underutilized crops play a pivotal role in advancing agroecological transitions by supporting the systematic changes needed to create more sustainable, resilient, and equitable food systems. By aligning with the five levels of agroecological transitions proposed by Gliessman (2020) and the 13 principles outlined by the High-Level Panel of Experts on Food Security and Nutrition (HLPE, 2019), underutilized crops actively contribute to transformative change at multiple scales.

Underutilized crops contribute to reducing external inputs such as synthetic fertilizers, pesticides, and irrigation water. Many underutilized crops, such as bere barley in Orkney, thrive in marginal conditions without reliance on chemical inputs, thanks to their genetic adaptations to local environments. This decrease in input dependency aligns with the agroecological principles of minimizing external inputs and improving soil and animal health, fostering more sustainable farming practices. Moreover, incorporating underutilized crops encourages the adoption of agroecological practices such as crop rotations, intercropping, and composting. For instance, farmer K in Terceira, Azores, has employed green manures, natural pest control, and composting circuits to enrich soil fertility and enhance farm productivity. These practices have replaced conventional inputs with ecologically sound alternatives, promoting synergy and recycling within the farming system.

Underutilized crops enable redesigning of farming systems to prioritize biodiversity and resilience. At farm 4, the montado system integrates oak forests, livestock, and underutilized crops like acorns into a cohesive agroecosystem that balances ecological and economic functions. Similarly, farm 2 in Hungary showcases how diversified systems built around underutilized crops stabilize agricultural production and foster functional biodiversity, demonstrating how redesigning farms around agroecological principles can enhance long-term resilience.

These interactions among various components of agrobiodiversity are not limited to the biological domain but are intricately embedded within broader socio-ecological systems (Lèon-Sicard et al., 2024). Farmers and their cultural practices play a central role in these systems, acting both as beneficiaries of the ecosystem

services provided by agrobiodiversity and as key agents responsible for its maintenance. It is critical to emphasize that these interactions manifest at multiple scales, from local to global, highlighting the dynamic relationships that underpin these systems and their potential for transformation.

Underutilized crops help to shorten food supply chains by fostering direct connections between producers and consumers. In Greece, farmers of case study 6 and those in Italy at farm 3 are building alternative food networks that connect local communities to culturally significant crops. These networks strengthen social values, promote fairness, and encourage participation, addressing key agroecological principles and enhancing food system governance.

Eventually, the adoption of underutilized crops supports a broader transformation of global food systems by challenging the dominance of monocultures and industrial agriculture. By promoting diverse diets, sustainable production practices, and localized food systems, underutilized crops address systemic inequities and environmental degradation. The rediscovery of acorns at farm 4 and the revival of bere barley in Orkney (1) exemplify how underutilized crops can catalyse systemic change, embedding agroecology into food systems and contributing to global sustainability goals.

These crops serve as catalysts for co-creating knowledge and integrating traditional practices with scientific innovations. This integration strengthens the foundations of agroecological transitions, ensuring that farming systems are not only productive but also equitable and sustainable. The adoption of underutilized crops is thus an essential strategy for advancing agroecology as a pathway to resilient food systems. Underutilized crops offer a tangible solution to the pressing challenges of climate change, agrobiodiversity loss, and food insecurity. Their role in fostering innovation, community engagement, and sustainability underscores their transformative potential in reshaping the future of agriculture and food systems.

## 14.4 Conclusions

This research underscores the transformative potential of underutilized crops in advancing agroecological transitions and building sustainable food systems. Underutilized crops contribute significantly to ecological, economic, and social resilience while addressing the challenges of agrobiodiversity loss and climate change.

The adoption and integration of underutilized crops highlight the visionary capacity of farmers to innovate and redesign agricultural systems. By blending traditional knowledge with innovative practices, these systems exemplify resilience, sustainability, and adaptability. Underutilized crops act as catalysts for transforming agricultural landscapes, fostering diverse, multifunctional agroecosystems that align with the principles of agroecology.

The mobilization of local knowledge is crucial for sustaining and advancing the use of underutilized crops. By drawing from centuries-old practices and

incorporating participatory research and co-created innovations, farmers ensure that underutilized crops are preserved and adapted to meet contemporary challenges. This integration of knowledge strengthens the link between cultural heritage and ecological stewardship, creating a foundation for resilient food systems.

Economically, underutilized crops diversify revenue streams and create new market opportunities. They align with global sustainability goals by fostering economic diversification and reinforcing food sovereignty. Socially, underutilized crops can enhance community bonds while reviving local and traditional practices, and contribute to diverse and sustainable diets.

Underutilized crops could play a foundational role in agroecological transitions. Their low input requirements, adaptability to diverse environmental conditions, and capacity to enhance ecosystem services align with key agroecological principles such as recycling, biodiversity, and sinergy. Underutilized crops support transitions across multiple levels, from reducing dependency on inputs and redesigning agroecosystems to transforming supply chains and global food systems. Their adoption have the potential to foster sustainable relationships between eaters and growers.

The broader scaling and adoption of underutilized crops require systemic support. Policies, research investments, and educational initiatives are essential to creating enabling environments for underutilized crops. Strengthening seed systems, promoting participatory approaches, and integrating agroecological education can ensure the long-term viability and impact of underutilized crops.

In conclusion, underutilized crops are indispensable in reimagining sustainable agriculture. By fostering innovation, promoting resilience, and embedding ecological and social equity into food systems, underutilized crops address pressing global challenges. Their integration into agroecological frameworks is crucial for creating a future that values biodiversity, sustainability, and fairness.

## References

Aworh, O. C. (2018). From lesser-known to super vegetables: The growing profile of African traditional leafy vegetables in promoting food security and wellness. *Journal of the Science of Food and Agriculture, 98*(10), 3609–3613. https://doi.org/10.1002/jsfa.8902

Barcaccia, G., Volpato, M., Gentili, R., Abeli, T., Galla, G., Orsenigo, S., Citterio, S., Sgorbati, S., & Rossi, G. (2016). Genetic identity of common buckwheat (*Fagopyrum esculentum Moench*) landraces locally cultivated in the Alps. *Genetic Resources and Crop Evolution, 63*(4), 639–651. https://doi.org/10.1007/s10722-015-0273-z

Bayudan, S., De Steur, H., & Schouteten, J. J. (2024). From niche to noteworthy: A multi-country study on consumer views towards neglected and underutilized crops. *International Journal of Gastronomy and Food Science, 38*(July). https://doi.org/10.1016/j.ijgfs.2024.101052

Canella, M., Ardenghi, N. M. G., Müller, J. V., Rossi, G., & Guzzon, F. (2022). An updated checklist of plant agrobiodiversity of northern Italy. *Genetic Resources and Crop Evolution, 69*(6), 2159–2178. https://doi.org/10.1007/s10722-022-01365-y

de Avila, J. E. T., Coelho, F. C., Sardo, P. M. Lo, Haddade, I. R., and Moonen, A. C. (2025). In situ conservation of agrobiodiversity carried out by traditional family farmers in a mountainous

region of Brazil. *Agroecology and Sustainable Food Systems*, 1–24. doi:https://doi.org/10.1080/21683565.2024.2445729.

Delbaere, B., Mikos, V., & Pulleman, M. (2014). European policy review: Functional agrobiodiversity supporting sustainable agriculture. *Journal for Nature Conservation, 22*(3), 193–194. https://doi.org/10.1016/j.jnc.2014.01.003

Elouafi, I. (2024). Why biodiversity matters in agriculture and food systems. *Science, 386*(6718), eads8197. https://doi.org/10.1126/science.ads8197

Fernández González, C., Ollivier, G., & Bellon, S. (2021). Transdisciplinarity in agroecology: Practices and perspectives in Europe. *Agroecology and Sustainable Food Systems, 45*(4), 523–550. https://doi.org/10.1080/21683565.2020.1842285

Gliessman, S. R. (2020). Transforming food and agriculture systems with agroecology. *Agriculture and Human Values, 37*(3), 547–548. https://doi.org/10.1007/s10460-020-10058-0

Guest, G., MacQueen, K. M., & Namey, E. E. (2011). *Applied thematic analysis*. Sage.

HLPE. (2019). Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. *A report by the high level panel of experts on food security and nutrition of the committee on world food security, Rome*. https://openknowledge.fao.org/server/api/core/bitstreams/ff385e60-0693-40fe-9a6b-79bbef05202c/content

Hunter, D., Borelli, T., Beltrame, D. M. O., Oliveira, C. N. S., Coradin, L., Wasike, V. W., Wasilwa, L., Mwai, J., Manjella, A., Samarasinghe, G. W. L., Madhujith, T., Nadeeshani, H. V. H., Tan, A., Ay, S. T., Güzelsoy, N., Lauridsen, N., Gee, E., & Tartanac, F. (2019). The potential of neglected and underutilized species for improving diets and nutrition. *Planta, 250*(3), 709–729. https://doi.org/10.1007/s00425-019-03169-4

Isbell, F., Adler, P. R., Eisenhauer, N., Fornara, D., Kimmel, K., Kremen, C., Letourneau, D. K., Liebman, M., Polley, H. W., Quijas, S., & Scherer-Lorenzen, M. (2017). Benefits of increasing plant diversity in sustainable agroecosystems. *Journal of Ecology, 105*(4), 871–879. https://doi.org/10.1111/1365-2745.12789

Jenkins, T., Landschoot, S., Dewitte, K., Haesaert, G., Reade, J., & Randall, N. (2023). Evidence of development of underutilised crops and their ecosystem services in Europe: A systematic mapping approach. *CABI Agriculture and Bioscience, 4*(1), 1–21. https://doi.org/10.1186/s43170-023-00194-y

Jones, S. K., Estrada-Carmona, N., Juventia, S. D., Dulloo, M. E., Laporte, M.-A., Villani, C., & Remans, R. (2021). Agrobiodiversity index scores show agrobiodiversity is underutilized in national food systems. *Nature Food, 2*(9), 712–723. https://doi.org/10.1038/s43016-021-00344-3

Kell, S., Rosenfeld, A., Cunningham, S., Dobbie, S., & Maxted, N. (2018). The benefits of exotic food crops cultivated by small-scale growers in the UK. *Renewable Agriculture and Food Systems, 33*(6), 569–584. https://doi.org/10.1017/S1742170517000424

Kennedy, G., Wang, Z., Maundu, P., & Hunter, D. (2022). The role of traditional knowledge and food biodiversity to transform modern food systems. *Trends in Food Science & Technology, 130*(September), 32–41. https://doi.org/10.1016/j.tifs.2022.09.011

León-Sicard, T. E., Griffon, D., & De Marchi, M. (2024). Editorial: Agrobiodiversity, community participation and landscapes in agroecology. *Frontiers in Sustainable Food Systems, 8*. https://doi.org/10.3389/fsufs.2024.1414397

Letourneau, D. K., Armbrecht, I., Rivera, B. S., Montoya, J., Carmona, E. J., Daza, M. C., Escobar, S., Galindo, V., Gutiérrez, C., López, S. D., Mejía, J. L., Maritza, A., Rangel, A., Rangel, J. H., Rivera, L., Saavedra, C. A., Torres, A. M., & Armbrecht, I. (2015). Does plant diversity benefit agroecosystems? A synthetic review published by: Ecological Society of America Linked references are available on JSTOR for this article: Your use of the JSTOR archive indicates your acceptance of the terms & conditions of. *Ecological Applications*, *21*(1), 9–21.

Mabhaudhi, T., Hlahla, S., Chimonyo, V. G. P., Henriksson, R., Chibarabada, T. P., Murugani, V. G., Groner, V. P., Tadele, Z., Sobratee, N., Slotow, R., Modi, A. T., Baudron, F., & Chivenge, P. (2022). Diversity and diversification: Ecosystem services derived from underutilized crops

and their co-benefits for sustainable agricultural landscapes and resilient food systems in Africa. *Frontiers in Agronomy, 4*(May), 1–17. https://doi.org/10.3389/fagro.2022.859223

Migliorini, P., Gkisakis, V., Gonzalvez, V., Raigón, M. D., & Bàrberi, P. (2018). Agroecology in mediterranean Europe: Genesis, state and perspectives. *Sustainability (Basel, Switzerland), 10*(8), 1–23. https://doi.org/10.3390/su10082724

Mudau, F. N., Chimonyo, V. G. P., Modi, A. T., & Mabhaudhi, T. (2022). Neglected and underutilised crops: A systematic review of their potential as food and herbal medicinal crops in South Africa. *Frontiers in Pharmacology, 12*(January), 1–31. https://doi.org/10.3389/fphar.2021.809866

Nicita, L., Bosello, F., Standardi, G., & Mendelsohn, R. (2024). An integrated assessment of the impact of agrobiodiversity on the economy of the Euro-Mediterranean region. *Ecological Economics, 218*, 108125. https://doi.org/10.1016/j.ecolecon.2024.108125

Padulosi, S., & Hoeschle-Zeledon, I. (2004). Underutilized plant species: What are they? *Leisa-Leusden, 20*, 5–6.

Pannacci, E., Lattanzi, B., & Tei, F. (2017). Non-chemical weed management strategies in minor crops: A review. *Crop Protection, 96*, 44–58. https://doi.org/10.1016/j.cropro.2017.01.012

Rasul, G., Hussain, A., Adhikari, L., & Molden, D. J. (2022). Conserving agrobiodiversity for sustainable food systems in the Hindu Kush Himalaya. *International Journal of Agricultural Sustainability, 20*(6), 1117–1135. https://doi.org/10.1080/14735903.2022.2057642

Revoredo-Giha, C., Toma, L., Akaichi, F., & Dawson, I. (2022). Exploring the effects of increasing underutilized crops on consumers' diets: The case of millet in Uganda. *Agricultural and Food Economics, 10*(1), 1–21. https://doi.org/10.1186/s40100-021-00206-3

Tamburini, G., Bommarco, R., Wanger, T. C., Kremen, C., Heijden, M. G. A. van der, Liebman, M., & Hallin, S. (2020). Agricultural diversification promotes multiple ecosystem services without compromising yield. *Science Advances*, November, 1–8.

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# Chapter 15
# Starting-Up Alternative Food Networks: The Implications of Profit-Driven Start-Ups Identifying as Alternative Food Networks in Germany




**Theresa Meyer**

**Abstract** Alternative food networks (AFNs) are at the core of amplifying agroecology. AFNs are commonly associated with initiatives that reject the neoliberal agenda of the supermarket system while empowering farmers and citizens through alternative market practices. However, as consumer demands for sustainable and locally sourced food are rising and AFNs are becoming popular in wider society, we see start-ups emerging which aim to capitalize on the promises of AFNs. Yet, it is unclear how these profit-driven actors can contribute to a political agroecological understanding which sees farmers and citizens as core agents in determining their own food system and practices. Therefore, semi-structured interviews with different start-ups in Germany were conducted to understand their role in scaling AFNs in Germany. The material was analysed through a coding framework guided by the multi-level perspective on transition pathways. The results show that the start-ups' strategies are highly diverse due to different degrees of regime interaction and therefore a categorization has been developed: the start-ups which oppose regime practices most are simultaneously committing most to AFNs values and might be a potential ally to the movement if questions of ownership and equal partnership are addressed. Yet, the movement must stay attentive that actors do not highjack their practices and missuse achieved societal trust.

**Keywords** Value-based supply chains · Multi-level perspective · Scaling-up · Localization · Sustainability transition · Agroecology

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## 15.1 Introduction

As the European food system fails to cope with its negative social and environmental externalities, a variety of stakeholders, including activists, practitioners, policymakers, and public and private entities, are looking for alternatives. Hence, agroecology is gaining traction as it encompasses a systems approach to transform the food system based on ecologically sound farming practices, a re-connection between consumers and producers, and a redesign of the socio-political system that includes power redistribution (Gliessman et al., 2023). However, the development of a European agroecological food system is still in its early stages. While numerous local initiatives are emerging, farmers are transitioning to agroecological practices, and discussions are underway in policymaking circles on how to facilitate this transition, agroecology has yet to be systematically implemented on a larger scale (Wezel & Gkisakis, 2023). Furthermore, the understanding of agroecological principles within the EU is by no means homogeneous. A wide range of influential governmental, scientific, private, and non-governmental organizations are struggling to define a 'European articulation of agroecology', resulting in competing notions of both practices and politics (Anderson et al., 2021).

The competing notions are increasingly being attributed to the usage by an ever-growing range of actors, leading to a dualistic opposition on agroecology (Penvern et al., 2023). Central to these debates lies how 'political' or system-transforming agroecology is understood: while current agri-food companies and some political entities view agroecology as a mere tool to make the industrial food system more sustainable, civil society advocates promote transformative agroecology as an alternative to the industrial food system. Transformative agroecology is not market-driven, and there are no certification systems or labels for its products so far. Additionally, there is no universally accepted definition or clear criteria for what qualifies as a production agroecological production (Migliorini & Wezel, 2017).

Therefore, it is not entirely clear which actors are associated with transformative agroecology, nor is it evident if these actors are gaining momentum. Especially, when considering the value chain, the emergence of alternative food networks (AFN) is considered as a promising transition pathway, formed in response to the commercialization of agriculture, in both research and practice (Born & Purcell, 2006). These networks are built around farmers and citizens who organize to promote alternative food distribution models for organic, local, and/or agroecological produce. In recent years, a new set of actors have emerged in Germany, identifying themselves as part of this alternative food distribution: these start-ups aim to localize the food system through novel business models while committing to the values of AFN. Here, start-ups are defined as newly founded businesses that seek growth and scalability through novel innovation practices that promise profitability (Cavallo et al., 2021). The specific novel innovations are diverse, ranging from box schemes and online markets to self-service stores and payment solutions for farm shops. These start-ups unite in digitalizing and modernizing the food system, promoting sustainably and socially just sourced local food. Contrary to traditional AFN actors,

these start-ups are not farmer- or citizen-driven; rather, they are profit-seeking companies. They blend a commitment to AFN normativity and sustainability with novel technologies and infrastructure of the commercial food system. Accordingly, they find themselves in the midst of the debate regarding who belongs to the agroecology movement in Europe and what their operations mean for the potential pathways of transformation of the European food system.

This study draws from the findings of my Master's thesis, which I successfully defended in May 2022 as part of the Environmental Studies and Sustainability Sciences programme at Lund University (Meyer, 2022). The research posed the question: *to what extent can value-based supply chain start-ups contribute to an agroecological transition of the German food system?* To investigate this question, I studied seven different businesses that aim to revolutionize the German food supply system through the distribution while being committed to the values of AFNs. The multi-level perspective (MLP) of sustainability transition studies (Geels, 2002) was operationalized to analyse to what transition pathway of the German food system their operation contributes. In this context, it will be discussed why it is important to engage with the visions, values, and operations of these actors to understand the emerging pathways towards agroecology and the implications for farmers and citizens.

### *15.1.1 Characteristics of AFN and Profit-Driven Start-Ups*

AFNs are defined by van der Ploeg et al. (2000) as eco-ethical driven agri-food economies, which, in contrast to the global agri-food economies, are built on new farming and food distribution practices aimed at transforming the food system. In this sense, they align with a transformative understanding of agroecology, which seeks to build a food system based on the principles of sustainability and justice.

While AFNs are diverse in their practical realization, several common themes can be identified: First, these networks promote farming practices based on territorial diversity, ecology, and multifunctionality to counter the environmental externalities of industrialized farming (Berti & Mulligan, 2016). AFNs go beyond the farm, redefining the relationship between actors within the food supply chains from production to consumption (Schneider et al., 2016). In these networks, farm products are marketed to consumers through short supply chains, which include farmers' markets, community-supported agriculture, solidarity-based purchasing groups, urban agriculture, and community gardens. These networks enable producers to sell their products directly to consumers (Berti & Mulligan, 2016). There is a strong emphasis on high-quality foods being marketed directly from producers to consumers, helping to ensure higher prices for the producers (Schneider et al., 2016).

Furthermore, they organize in a cooperative manner, which agroecologists view as a key to re-distributing power, as noted by DeMolina et al. (2020). This framework places the producers and citizens as the main agents in the food chain. However, the AFN literature shows that this transformative re-structuring fails to

meet the expectations associated with it, due to several barriers faced by small- and medium-sized farms when restructuring, especially in highly industrialized and corporate systems in the Global North (Rucabado-Palomar & Cuéllar-Padilla, 2020). The strong focus on shortening the food supply chain requires the infrastructure that allows farmers to sell their products directly to consumers. However, this is time-consuming and labour-intensive (Seyfang & Smith, 2007), and the current system, especially in Germany, is characterized by a few, large supermarket chains with long supply chains, which do not incentivize or encourage direct sales (Schrode et al., n.d.). Therefore, the effectiveness of scaling up AFSs beyond the niche market has been called into question (Forssell & Lankoski, 2015).

Born and Purcell (2006) criticized AFN for confusing the scale of the supply chain (e.g. local versus global) with sustainable production, which they termed as the 'local trap'. While localizing should be acknowledged as an aspect of a sustainability transition, the scale itself does not inherently guarantee ecological sustainability, social justice, freshness, or quality (Born & Purcell, 2006). Building on this critique, Forsell and Lankoski (2015) conducted a literature review examining the sustainability and justice impacts of AFNs beyond the local scale. They identify a diverse set of AFN characteristics—such as environmentally benign and territorially embedded production, the reduction of physical and relational distances within value chains, and alternative governance arrangements based on trust, resource sharing, and power redistribution. These characteristics were found to generate a wide range of environmental, economic, and social impacts: AFNs are associated with environmental benefits including reduced food miles and support for organic and animal welfare-oriented production practices. Additionally, they have economic effects such as added value for producers, job creation, strengthened local economies, and reduced market risks. Social outcomes including stronger consumer and producer relations enhanced food awareness and the preservation of traditional and regional practices. Beyond these direct impacts, the authors also emphasize indirect effects, particularly increased learning, participation, and social embeddedness within food systems, which can foster more informed, aware, and empowered consumers and producers. Therefore, the diffusion of AFN operational norms may have the potential to scale sustainable and fair food systems by committing to the values and characteristics of AFN among actors outside of the AFN group.

Value-based supply chains (VBSC) follow the promise of traditional AFSs' environmental and socio-economic benefits but broaden the supply chain to include more actors and intermediaries (Dimitri & Gardner, 2019). Start-ups can be classified as VBSC because they emphasize the values inherent to these systems and can therefore help overcome local. These supply chains may include members from the conventional system if they are willing to incorporate the values of AFNs (Fleury et al., 2016). Unlike farmer-citizen marketing, VBSCs include intermediaries that do not directly engage in food production, opening a new dimension to AFNs that has only been studied to a lesser extent.

This is relevant because Clark and Inwood (2016) found that as retailers scale up, their distribution channels are getting streamlined and formalized. This process can lead to a decline in commitment to trusting relationships and a shift away from

the local scope, which was the initial aim and the core value of AFSs. Although there is a general optimism that consumers will be willing to pay higher and more equitable prices for additional environmental and socio-economic benefits, in practice, paying higher prices can lead to trade-offs (Dimitri & Gardner, 2019).

Thus, it is essential to carefully analyse the ability to stay committed to value-based relationships when studying new VBSC actors. This is especially important considering that farmers and consumers are not the main agents in this system; instead, companies that aim to commercialize AFN play a central role. It poses the question of how these companies can be understood through the lens of agroecology. Despite this query, it is argued that it is important to study these actors, as they may influence the transition pathways emerging in the food system. However, whether this is the case here requires further examination, particularly since the studies concentrating on entrepreneurs from outside farmers' communities have primarily focused on the United States (Dimitri & Gardner, 2019). Therefore, to understand how we can study transition pathways emerging based on the understanding of the actors, the MLP will be introduced now.

## 15.2 Theoretical Framework: Multi-Level Perspective

The MLP studies changes in the socio-technical dominant system through interactions across three levels: the landscape, the socio-technical regime, and niche innovation (Darnhofer, 2015; Geels, 2002). The term 'socio-technical' encompasses both technological and social innovations, including the changing norms and rules that are 'intangible and underlying deep structures' (Geels, 2011, p. 31). A key assumption of socio-technical change is that niche actors can develop innovations in somewhat protected spaces. These innovations can gradually gain momentum by forming connections through co-construction. If the regime fails to respond to a changing landscape, the niche innovations may ultimately replace the existing regime practices (Geels, 2002). Through the interplay of these factors, different transition pathways occur in which the regime either stabilizes, incorporates the niche, or gets replaced (Geels & Schot, 2007) (Fig. 15.1).

### *15.2.1 Niche-Regime Interaction*

The socio-technical regime is classified as the dominant system, comprising a relatively stable entity made up of actors from the market, science, policy, and technology. These actors operate based on shared structures, cultures, and norms (Marsden, 2013). Although the regime level has only been briefly studied in food system literature (El Bilali, 2019), it features an intensive and industrial food sector with global supply chains (Marsden, 2013). The food regime is characterized by a high degree of lock-ins, which are processes that systemically exclude competing technologies,

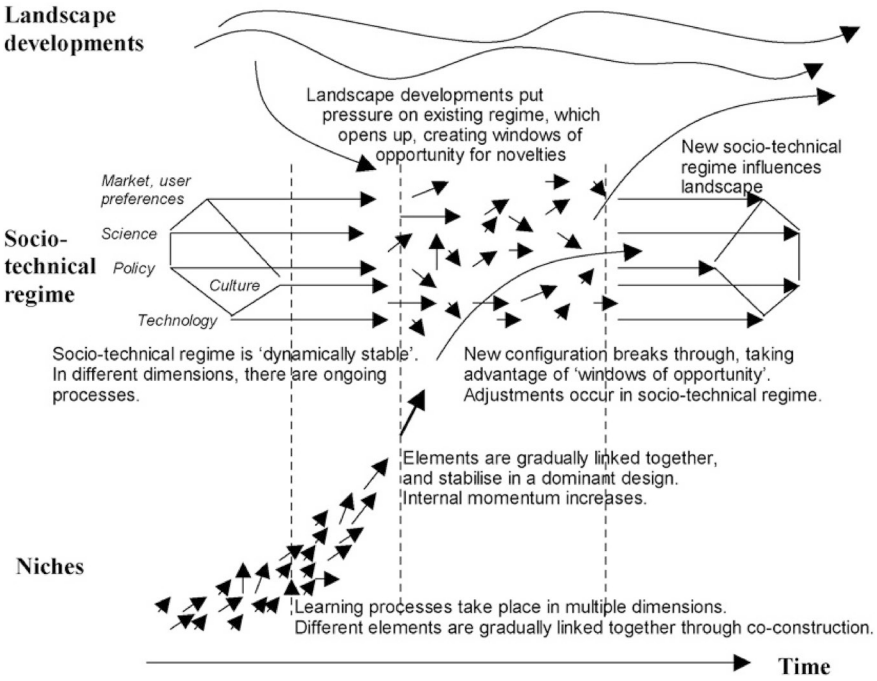



**Fig. 15.1** Multi-level perspective by Geels. Source: (Geels, 2002, p. 915). *Note.* Change in the system is attributed to the regime's incapability to deal with landscape pressures, and niche-level initiatives that are better to deal with the landscape pressures can gain momentum: Niches are seen as outside of the dominant regime and are sources of innovation and change as they offer solutions to landscape pressures which the regime is unable to deal with.

viewpoints, and practices. This creates resistance from within the regime that may potentially lead to a lack of awareness regarding changes in the landscape (El Bilali, 2019).

The niche in food system research is not clearly defined and often used interchangeably with the term alternative agro-food systems (El Bilali, 2019). Generally, the term refers to 'new technologies, new rules and legislation, new organizations or even new projects, concepts or ideas' (Loorbach & Rotmans, 2006, p. 20). In the context of agriculture, it has primarily been used to examine transitions towards organic farming (El Bilali, 2019). In this study, I define start-ups as niche actors among a broad range of stakeholders with the aim of transitioning the food system, potentially with divergent goals. This perspective draws on an individual agency approach, which is described as 'motivations, beliefs and values of individual agents steering or influencing the transition pathways' (Vivero-Pol, 2017, p. 5).

Niche actors in the food system often exhibit 'hybrid' characteristics, adopting roles, infrastructure, and practices from both the niche and regime levels, although the extent of the adoption differs (Sutherland et al., 2015). Empowerment strategies among these actors include different niche-regime relationships. Some actors

conform to mainstream socio-technical practices, fitting into the existing practices, while others challenge and transform by undermining regime practices through innovative business models, which are referred to as niche-deprived practices (Smith & Raven, 2012).

Landscape pressures are diverse and have largely been overlooked in research (El Bilali, 2019). For this study, the landscape pressures were identified by the start-ups will be discussed in the results section. Following the individual agency understanding, I will refrain from delving into how these pressures have been studied in other contexts.

### *15.2.2 Transition Pathways and Scaling-up*

Transition pathways depend on the timing and nature of interaction among the three levels (Geels & Schot, 2007). Geels and Schot's typology (2007) indicates that the transition rarely means that one niche actor replaces the regime. Therefore, transition patterns of the food system are pluralistic, with several transition pathways unfolding simultaneously (Ingram et al., 2015). These pathways enable knowledge exchange through networking, even if niche actors do not integrate into the regime.

Scaling-up is a mechanism designed to broaden niche innovations, facilitating transition towards seeking to achieve more impact through expansion and replication (Pitt & Jones, 2016). As AFN aims to counter these monopolistic mechanisms, it needs to scale horizontally to increase the overall volume while addressing the intended social, economic, and environmental impacts within the food system (Clark & Inwood, 2016).

Vivero-Pol (2017) classified niche actors into reformists and transformists. Reformists aim for moderate changes and adjustments and seek to shift the structure while leaving the core features untouched. On the other hand, transformists aim for drastic structural changes and seek to re-negotiate core values and power balances (Vivero-Pol, 2017). These differing empowerment strategies influence transition pathways. Reformists fall into Duncan and Pascucci's categorization (2017) of isomorphic AFN, which are more likely to adopt practices from the dominant regime, ranging from formalized participation rules to organizational forms. While this may foster a stronger agency to scale up their business, the pressures to align can lead them to lose their normative stands to some degree over time (Duncan & Pascucci, 2017). Transformists, in contrast, fall into the category of polymorphic AFN as their beliefs include changes in the very structure of the system, making them less likely to conform to the dominant regime. Consequently, while it may be harder for them to influence the regime, if successful, they can promote more radical changes (Duncan & Pascucci, 2017).

## 15.3 Method

The theoretical underpinnings of transformist and reformist VBSC-actors, as well as the tensions in niche-regime interaction in transition pathways, are important analytical tools to understand how start-ups contribute to the sustainability transition of the German food system and how they can be understood as actors of change for agroecology. Semi-structured interviews were conducted with members of the seven participating start-ups. The overall goal was to gain an understanding of the start-up, including its motivation, beliefs, and values, as these can and do differ among actors and influence how specific AFSs are adopted (Vivero-Pol, 2017). During the interview process, several ethical principles were considered. Participation was voluntary, and participants were informed about the research purpose of the study.

### *15.3.1 Case and Data Selection*

The term *'start-up'* remains somewhat undefined in academic discourses (Cockayne, 2019). Nonetheless, it is evident that it refers to newly founded businesses that aim to grow and scale through novel innovation practices with the promise of profitability and growth (Cavallo et al., 2021). Accordingly, the start-ups chosen shared some common variables: they all are engaged in different types of local food distribution and advertised their work as local and sustainable through novel marketing practices. They articulated the aim to extend their operation in the coming years. Another variable considered was that all the start-ups were geographically focused on operating in Germany.

Germany was selected for this study for several reasons. A report of the German environmental ministry concluded that the entire German food system, from seed production to consumption and disposal of food, is not sustainable (Schrode et al., n.d.). Schrode et al. (2012) identified that the current state of the German food system is characterized by rationalization, specialization, and concentration, driven by economic, political, and social path dependencies. Hence, strong lock-ins are observed at the regime level while these start-ups are being formed (Table 15.1).

**Table 15.1** Participating start-ups

| Start-up code | Interviewee | Founding year | Business model |
|---|---|---|---|
| SU1 | Founder | 2020 | Self-serving stores in containers with a mainly local product range, which should cover daily grocery shopping |

(continued)

**Table 15.1** (continued)

| Start-up code | Interviewee | Founding year | Business model |
|---|---|---|---|
| SU2 | Co-founder | 2021 | Digitalizing and modernizing the direct selling of farmers through providing a simple cash-free payment option, which funds a connected platform where consumers can find direct-selling farms |
| SU3 | Founder | 1996 | (mainly local) box scheme with exclusively organic products, where customers order online and get the boxes delivered |
| SU4 | Founder | 2016 | Ethically and sustainably sourced meat production, which is locally sourced and delivered Germany-wide through mail |
| SU5 | Employee | 2021 | Online store for organic, local, and seasonal products, which are being delivered to customers |
| SU6 | Head of brand and communication | 2014 (started operating in Germany in 2020) | Online supermarket with 30% local food and a delivery time of max. 4 h |
| SU7 | Co-founder | 2021 | Online store for mainly local products, which cover daily grocery shopping and are being delivered to customer |

*Note*. The table shows all participating start-ups, the person interviewed, their founding year, and their specific business model. While their specific business models are diverse, they are united in the goal of selling local products that are produced sustainably

## 15.4 Results and Discussion

The seven start-ups were classified according to Duncan and Pascucci's (2017) categorisation from reformist to transformist emerging pathways. This classification was based on their understanding of the interaction between the regime and the landscape, examining the extent to which they adopt dominant regime practices, the niche innovation they utilize, and the empowerment strategies they observed. From the analysis, three groups emerged: Group 1 'the alternative supermarket', Group 2 'daily local grocery shopping alternative', and Group 3 'alternative food contributors'. The following section provides an in-depth exploration of these different categories, outlining their emergence and the potential for scaling up, particularly in the context of transitioning towards agroecology in Germany.

### *15.4.1 Reformers and Transformers of the German Food System*

All start-ups were critical of the current regime, though to varying degrees. They defined the current regime as a supermarket infrastructure focused on streamlined distribution. The interactions between the regime and the landscape were described as a trade-off between sustainability and convenience. While the supermarket regime offered affordability and convenience for consumers, its negative externalities outweigh the positive aspects. However, the drivers of landscape pressures on the system were understood differently among the groups.

Group 1 (SU6) understood that the pressure is arising from the consumers who are becoming more environmentally aware of the negative externalities of the food system. Accordingly, they see the biggest challenge for the supermarkets as the need to respond to changing consumer demands in terms of both sustainability and convenience, especially as digitalization is offering new delivery and ordering models.

Groups 2 (SU1, SU3, SU7) and Group 3 (SU2, SU4, SU5) were more critical of the market power held by supermarket chains and their centralized food supply chain, which has led to a paradigm prioritizing 'price over quality'. Generally, consumers are described as being unaware of the issues within the system, lacking knowledge about food, and being increasingly disconnected from the production processes. Another feature the start-ups critically observed was the global value chains of products sold by supermarkets. While these chains provide convenience for consumers, the long transportation routes are deemed unsustainable and favour cheap food over locally sourced options. Furthermore, three start-ups mentioned that political support for big players in the system, bolstered by heavy lobbying, further strengthens the regime actors.

Nonetheless, supermarkets are struggling to address landscape pressures effectively. Start-ups have observed detrimental effects on natural resources, including biodiversity loss from large-scale farming and increased $CO_2$ emissions due to transportation, describing these issues as unsustainable. While there is increasing consumer awareness, Group 2 does not see it as important as Group 1 does. Instead of aiming to replace the supermarket regime, Group 2 aims to lower its dominance. All three start-ups aim to transform the daily grocery shopping experience by promoting small distribution channels that focus on local, environmentally friendly products. They envision reforming supermarkets to specialize in products that cannot be produced locally and non-food staples.

Group 3 has a systematic understanding of how unfair power dynamics and environmental degradation are interconnected. They view not only the marketing and distribution of products as unsustainable and unjust, but also the entire chain from production to consumption. Their aim is to transform the food system from the farm to Table 15.2.

**Table 15.2** Typology of start-ups based on transition pathway literature

| | Group 1 -alt. Super-market | Group 2 - daily, local grocery alternative | | | Group 3 - Alternative food contributors | | |
|---|---|---|---|---|---|---|---|
| *Start-up* | *SU6* | *SU1* | *SU3* | *SU7* | *SU4* | *SU2* | *SU5* |
| *Main regime-landscape interaction* | Pressures deprive from consumer pressures | Regime unable to create fair relations | Industrial farming and env. Degradation | Regime unable to create fair relations | In- transparent meat production; lack of animal welfare | Exploitation of producers/ Farmer in super-market system | Exploitation of people and nature through super-market system |
| *Adaptation of dominant regime practices and beliefs* | Complete supermarket range<br>Central logistic | Convenience of regime partially imitated<br>Buying from wholesalers | Convenience of regime partially imitated<br>Buying from wholesalers | Convenience of regime partially imitated | Infra-structure of meat production (e.g. slaughter-houses) | Payment provider using common payment methods | Organic certification |
| *Niche innovation* | 30% locally sourced products<br>E- supermarket with larger product range | Majority is locally produced<br>Self-serving stores | Organic certified products<br>Box scheme through online order system | Eliminating wholesaler<br>E-commerce | Localizing meat processing, personally selecting processors<br>Producing based on demand<br>E-commerce | Providing new infra-structure for direct selling farms<br>Exclusively local<br>Self-serving stores | Local, seasonal range of products<br>Eliminating wholesalers<br>E-commerce |
| *Regime-niche interaction* | Interact and collide | Limited interaction | | | Opposing and separating | | |
| *Empowerment strategy* | Adopting dominant practices | Adopting dominant socio-technical practices combined while implementing niche-derived practices | | | Undermining the incumbent regime and transmitting niche-derived<br>Practices and norms into it | | |

(continued)

**Table 15.2** (continued)

| | Group 1 -alt. Super-market | Group 2 - daily, local grocery alternative | | | Group 3 - Alternative food contributors | | |
|---|---|---|---|---|---|---|---|
| *Start-up* | *SU6* | *SU1* | *SU3* | *SU7* | *SU4* | *SU2* | *SU5* |
| *Classification of transition pathway* | Reformist | | | | Transformist | | |

*Note*. The table shows how their understanding of landscape-regime interaction influences how they adapt dominant regime practices and combine them with their own niche innovation. Dominant regime practices refer to the infrastructure of the regime, such as payment providers, certification schemes, logistics, or a food supply chain buying from wholesalers. They include cultural norms of the regime, for example, delivering the convenience it provides for customers. Niche innovations refer to the commitment to AFN norms and their digital innovations. The different extent of niche innovation and regime practices combined with their understanding of landscape-regime interaction led to a classification of used empowerment strategies based on Duncan and Pascucci's (2017) categorization.The transition pathway was categorized based on Vivero-Pol's (2017).

### *15.4.2 Niche Innovation*

All actors see direct-selling farmers as niche actors best suited to deal with the landscape pressures of environmental degradation and fair pricing. However, as described by SU1, these farmers often provide maximum authenticity but minimum convenience, which hinders their broader appeal. In response, start-ups position themselves as mediators between consumers and producers, aiming to innovate a system that enhances convenience through technological innovation while providing the positive aspects of direct-selling farmers, who are more ideal in tackling these landscape pressures. They adhere to the VBSC paradigm, seeking to unite actors based on shared values, as argued by Fleury et al. (2016). While technological innovations have been secondary in focus, the emphasis has primarily been on AFN characteristics. The following section will discuss the different approaches in the context of sustainable food and fair pricing, exemplifying what transition pathways for agroecology may evolve through these start-ups.

#### 15.4.2.1 Local and/or Organic Food

Interestingly, neither group made a clear commitment to exclusively sell organic-certified products. Group 1's start-up committed to having 30% of its product range be organic, along with a commitment to 30% local products. Products could qualify for both categories, but were not required to. These items were often added to the existing commercial product range. Furthermore, the group emphasized providing their customers with more information about the origins of the local and organic products, enabling them to make informed choices about which products to support. This shows a strong commitment to the current practices in the industry, with only slight reforms aimed at scaling their businesses.

In Group 2, the discussion around organic and local sourcing was strong: SU3 exclusively sells organic-certified products, while others aim for environmentally friendly production, offering both organic-certified and non-certified products. Their reasoning ranged from questioning the requirements for organic certification to wanting to include local farmers who may not be certified organic but still produce sustainably. Furthermore, the convenience aspect for customers also played a role as they sought to provide customers a choice and offer them a broad range of products, making it difficult to offer exclusively products that are local and organic. However, they maintained that they could take an open approach to environmentally friendly products due to their spatial connectiveness, allowing for personal oversight of production, which they individually assess for sustainability on a case-by-case basis. SU4 noted that when personal oversight is not possible, for example, citrus fruits sourced from Italy or Spain in the winter, they then must be organic-certified since individual control could not be exercised.

In Group 3, two start-ups exclusively sell organic products, while the other start-up does not sell products directly to the consumer. Instead, it offers a marketing

platform for direct sellers. However, they plan to introduce a certification mechanism on the platform to show which farmers use organic farming practices or other sustainable methods.

For all start-ups, trust and personal contact are seen as the primary mechanisms for ensuring environmental sustainability. Especially for the non-exclusively organic start-ups, trust and personal contact serve as substitutes for formal certification. Literature suggests that trusting relationships allow these start-ups to maintain flexibility regarding certification schemes, enabling them to use their personal connection with the farmers to determine whether a production system can be considered sustainable (Clark & Inwood, 2016). Such practices offer a low entry point, especially for small-scale farmers or those transitioning to organic agriculture who may not yet be certified. This approach aligns with agroecology, where current certification systems or labels, are not desired and there is no universally accepted definition or clear thresholds for what constitutes agroecological production (Migliorini & Wezel, 2017). However, contrary to participatory guarantee systems where citizens guarantee the products without having an economic interest in their marketing, the start-ups decide based on their personal justment and without clear guidelines who to include and who not. This difference becomes particularly relevant when discussing the issue of power redistribution.

#### 15.4.2.2 Fair Relations and Power re-Distribution

All start-ups claimed to have mechanisms in place to guarantee fair prices and the autonomy of farmers. It is important to note that farmers and consumers perspectives were not included in this study. Therefore, no conclusions can be made about their perspectives on these relationships. The mechanisms employed by the different groups varied significantly. Group 1 has a programme in place for local products that includes shorter contracts with local producers, faster payout times, and assistance with digitizing the farm's EDI tools. They emphasized that farmers and producers can communicate fluctuating product amounts, and the start-up would adapt flexibly to these changes.

Group 2 argued that personal contact with the producers naturally leads to more transparent and fair negotiations. They claimed that due to shorter supply chains, the producer and the start-up would have higher margins than regime actors, which helps maintain flatter hierarchies. Furthermore, two members stated that they do not engage in price negotiations, allowing producers to dictate prices, which they reported works well.

Similarly, Group 3 also believed this approach works well, as farmers understand the value of their products and would not overcharge. SU4 mentioned that they have specific prices in mind that most farmers consider fair. When there are disagreements regarding pricing, they communicate to find a mutually agreeable solution. As SU4 processes the meat after purchasing it from farmers, they operate under a different set of fixed costs compared to the other start-ups.

The strong focus on personal contact and trust creates potential tension as start-ups grow and may no longer guarantee the same level of personal control. Since no official collectives of farmers have been established to strengthen the producers' power structurally, these producers must rely on the trust that the start-ups will continue to operate in their current manner. This issue is specifically relevant for developing agroecology in Germany, especially if the aim is to strengthen the sovereignty of farmers. Contrary to cooperative AFN, start-ups provide farmers with the advantage of not having to build their direct-selling infrastructure or invest additional time and effort. However, as the start-ups primarily function as suppliers, they tend to keep farmers in the role of producers. The literature review indicates that this issue can lead to tensions, as seen by Milestad et al. (2017), and the trade-off observed needs to be studied further.

The analysis of how AFN characteristics were incorporated by the three groups showed that the transformist group exhibited the strongest commitment to agroecology, while the reformist group showed the least commitment in terms of its full product range, consistent with findings from previous research (Vivero-Pol, 2017). Drawing from transition pathways, it appears that reformist AFSs have a higher likelihood of success in scaling to the regime level, whereas transformist AFSs face greater challenges in influencing the existing regime. However, if transformists are successful, they can promote radical changes (Duncan & Pascucci, 2017). Accordingly, the next section will discuss how different commitments to AFNs' characteristics, combined with different empowerment strategies, can scale up AFNs in Germany.

### *15.4.3 Scaling-up Experiences: Opportunities and Constraints*

Scaling AFNs is difficult due to its commitment to localizing the supply chain. Accordingly, rather than having one niche actor scaling up vertically, a horizontal scaling-up process is preferred. The start-ups agreed that vertical scaling processes were limited due to the localized food system approach, similar to how it has been observed by Pitt and Jones (2016).

Therefore, three different strategies emerged across all three groups: SU7, SU4, and SU6 seek to expand by opening new businesses in new localities, utilizing new logistics and producers. On the other hand, SU1 and SU2 have adopted a franchise model, providing the necessary infrastructure to self-employed owners. SU5 and SU3 focus on expanding their customer base within the region rather than expanding to new cities. Drawing from the findings of Clark and Inwood (2016), these strategies can scale up the overall volume, increasing transparency and fostering strategic partnerships throughout the supply chain. Additionally, they intend to impact the social, economic, and environmental aspects of the food system, rather than solely focusing on economic efficiency.

The degree to which the start-ups expressed a desire to scale up their operation varied: Group 1/SU6 set an ambitious goal of achieving a 30% market share in

Germany by 2030. This isomorphic empowerment strategy (Duncan & Pasucci, 2017) is likely to facilitate successful scaling. However, considering the core characteristic of AFN, to counter the monopolistic nature of the food system, it raises questions about how such market concentration can genuinely commit to AFN's core characteristics, especially since they show the least commitment to AFN.

The other two groups were less ambitious but indicated potential for growth in their business models growing in the future and a desire to expand. Group 2 envisioned their business models as capable of handling daily grocery shopping in the future. However, they did not aim to replace supermarkets. They realistically questioned whether they could reach a broad customer base through their business. While they could help facilitate a shift in food culture by informing and educating consumers, they acknowledged that a complete shift in societal mindset would only be possible with the involvement of political and social stakeholders. The start-ups give politics only a minor role in transitioning, but previous research indicates that supportive governance structures are essential for niche innovation to succeed in sustainability transitions (Geels, 2020). Group 3 identified the potential to expand their initiatives to a broader scale, although they acknowledged that this would not replace supermarkets. In contrast, SU4 and SU2, which operate within a more specialised arena (e.g. meat production) than the other start-ups, saw their potential for scaling up to the regime level as quite restricted. SU2 aims to digitalize and modernize the direct-selling system and believes that while more consumers will likely purchase directly from farmers in the future, this will only represent a part of a society capable of managing the "inconvenience" of buying from farms. SU5 expressed a similar viewpoint. As being the most stringent in their commitment to local products, they question how to effectively balance their values with the convenience that customers expect.

While this group proposes a more radical change due to their operational system and commitment to AFN values, they focus on specific arenas within the food system and are not aiming to replace the whole regime level. Furthermore, even within their chosen areas, they question whether such a strong commitment to AFN characteristics contributes to broader systemic change. Nonetheless, niche initiatives can also influence the regime by promoting learning and challenging the operations of regime actors (Seyfang & Haxeltine, 2012). As a result, these initiatives can be seen as catalysts for innovation, challenging established practices while remaining a niche actor. For instance, SU5's internal discussions show that while they may not be able to transition into a regime-level player, they can still contribute to a shift in the regime through avenues such as activism or the development of new local food structures.

## 15.5 Contribution to Scaling-up Agroecology in Germany

Turning to the main question on how VBSC start-ups can contribute to an agroecological transition of the German food system, we need to piece the findings together. The niche represented by VBSC start-ups is diverse, and they cannot be treated as a single entity. Instead, it is their varying engagement with the regime level and their distinct empowerment strategies—ranging from reformist to transformist—that make them significant players in agroecology. For example, SU6 has a reformist nature, incorporating AFN characteristics in only 30% of its product. While this approach may not lead to a transformist pathway, adapting dominant practices, such as offering a broad product range, gives them the potential to scale fast. However, it is important to understand this as a gradual adoption to consumer awareness of prevailing regime practices, rather than a niche that is replacing the regime. It must be examined whether this can be rather classified as a stabilizing strategy of the regime instead of regime change strategies. Groups 2 and 3 may face more challenges moving beyond their niche due to a higher price range, limited product offerings, or less convenient shopping experiences. This is especially relevant in the German food system, which is characterized by a high degree of lock-ins and dominated by a few large players, potentially leading to a disregard for landscape pressures (Geels & Schot, 2007).

For the development of agroecology in Germany and other highly industrialized states with a corporate food regime, it is important to engage with these actors to understand the desirability of their business innovations. On one hand, these innovations can broaden the range of actors and food distribution channels, which is beneficial in a concentrated value-chain system. Furthermore, they also offer farmers who lack the resources to engage in direct marketing or cooperatives with opportunities to market their sustainably produced products at higher margins than supermarkets would offer. This is significant in a food system context where most farmers have specialized in a limited number of crops and will need to undergo a gradual transition. Yet, the biggest trade-off is the agency of farmers and citizens in these business models. While the start-ups aim to give more agency and negotiation power to the farmers and empower citizens by providing more information, they can also change their own rules and operations as they see fit, without any control mechanisms from third parties. Previous research has noted instances of commitments being softened (Milestad et al., 2017), which highlights the importance of discussing how farmers' unions or cooperative structures could be included in these business models. Accordingly, the question is not whether the niche is sufficiently developed to transition the food system. Instead, it is essential to explore whether there is room within this niche for various types of social and technical innovation and whether these innovations can interact with each other and learn from one another (Audet et al., 2017). Given that the niche is relatively small and has actually declined in recent years due to the economic crisis, it will also be important to understand how CSA's, box schemes, farmers' markets, and direct-selling evolve in

relation to the emerging start-ups and whether they are in competition with one another.

It is essential for agroecologists to broaden the scope of actors studied in the realm of alternative farming and food systems. This broader understanding will shed light on which developments are promoting transformative agroecology and which are stabilizing the current regime.

Due to the limited sample and scope of this study focusing solemnly on the perceptions of start-ups, further research is needed to explore the identified potential for scaling up and to determine whether windows of opportunity for transformist AFN scaling exist. The findings should also be tested in various countries and local contexts to draw broader conclusions about how VBSC start-ups can be an actor of change in scaling up AFSs. The proposed typology of groups can facilitate the replication of this study in different locations. Furthermore, it is important to include more perspectives and actors within the food chain. Future research should specifically include the producers' and consumers' side, and it would also be valuable to conduct a more in-depth study of start-ups to better understand their internal discussions regarding scaling-up processes.

## References

Anderson, C. R., Bruil, J., Chappell, M. J., Kiss, C., & Pimbert, M. P. (2021). *Agroecology now! Transformations towards more just and sustainable food systems* (1st ed.). https://doi.org/10.1007/978-3-030-61315-0

Audet, R., Lefèvre, S., Brisebois, É., & El-Jed, M. (2017). Structuring tensions and key relations of Montreal seasonal food Markets in the Sustainability Transition of the Agri-food sector. *Sustainability, 9*(3), 320. https://doi.org/10.3390/su9030320

Berti, G., & Mulligan, C. (2016). Competitiveness of small farms and innovative food supply chains: The role of food hubs in creating sustainable regional and local food systems. *Sustainability, 8*(7), 616. https://doi.org/10.3390/su8070616

Born, B., & Purcell, M. (2006). Avoiding the local trap. *Journal of Planning Education and Research, 26*(2), 195–207. https://doi.org/10.1177/0739456X06291389

Cavallo, A., Ghezzi, A., & Rossi-Lamastra, C. (2021). Small-medium enterprises and innovative startups in entrepreneurial ecosystems: Exploring an under-remarked relation. *International Entrepreneurship and Management Journal, 17*(4), 1843–1866. https://doi.org/10.1007/s11365-020-00698-3

Clark, J. K., & Inwood, S. M. (2016). Scaling-up regional fruit and vegetable distribution: Potential for adaptive change in the food system. *Agriculture and Human Values, 33*(3), 503–519. https://doi.org/10.1007/s10460-015-9618-7

Cockayne, D. (2019). What is a startup firm? A methodological and epistemological investigation into research objects in economic geography. *Geoforum, 107*, 77–87. https://doi.org/10.1016/j.geoforum.2019.10.009

Darnhofer, I. (2015). Socio-technical transitions in farming: Key concepts. In L.-A. Sutherland, I. Darnhofer, & G. A. Wilson (Eds.), *Transition pathways towards sustainability in agriculture: Case studies from Europe* (pp. 17–31). CABI. https://doi.org/10.1079/9781780642192.0017

DeMolina, M. G., Petersen, P. F., Garrido Peña, F., & Caporal, F. R. (2020). *Political agroecology: Advancing the transition to sustainable food systems. Advances in agroecology*. CRC Press.

Dimitri, C., & Gardner, K. (2019). Farmer use of intermediated market channels: A review. *Renewable Agriculture and Food Systems, 34*(03), 181–197. https://doi.org/10.1017/S1742170518000182

Duncan, J., & Pascucci, S. (2017). Mapping the Organisational forms of networks of alternative food networks: Implications for transition. *Sociologia Ruralis, 57*(3), 316–339. https://doi.org/10.1111/soru.12167

El Bilali, H. (2019). The multi-level perspective in research on sustainability transitions in agriculture and food systems: A systematic review. *Agriculture, 9*(4), 74. https://doi.org/10.3390/agriculture9040074

Fleury, P., Lev, L., Brives, H., Chazoule, C., & Désolé, M. (2016). Developing mid-tier supply chains (France) and values-based food supply chains (USA): A comparison of motivations, achievements, Barriers and Limitations. *Agriculture, 6*(3), 36. https://doi.org/10.3390/agriculture6030036

Forssell, S., & Lankoski, L. (2015). The sustainability promise of alternative food networks: An examination through "alternative" characteristics. *Agriculture and Human Values, 32*(1), 63–75. https://doi.org/10.1007/s10460-014-9516-4

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy, 31*(8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions, 1*(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002

Geels, F. W. (2020). Micro-foundations of the multi-level perspective on socio-technical transitions: Developing a multi-dimensional model of agency through crossovers between social constructivism, evolutionary economics and neo-institutional theory. *Technological Forecasting and Social Change, 152*, 119894. https://doi.org/10.1016/j.techfore.2019.119894

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy, 36*(3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003

Gliessman, S. R., Méndez, V. E., Izzo, V. M., & Engles, E. (2023). *Agroecology: Leading the transformation to a just and sustainable food system* (4th ed.). CRC Press.

Ingram, J., Maye, D., Kirwan, J., Curry, N., & Kubinakova, K. (2015). Interactions between niche and regime: An analysis of learning and innovation networks for sustainable agriculture across Europe. *The Journal of Agricultural Education and Extension, 21*(1), 55–71. https://doi.org/10.1080/1389224X.2014.991114

Loorbach, D., & Rotmans, J. (2006). Managing transitions for sustainable development. In X. Olsthoorn & A. J. Wieczorek (Eds.), *Environment & Policy: Vol. 44. Understanding industrial transformation* (pp. 187–206). Kluwer Academic Publishers. https://doi.org/10.1007/1-4020-4418-6_10

Marsden, T. (2013). From post-productionism to reflexive governance: Contested transitions in securing more sustainable food futures. *Journal of Rural Studies, 29*, 123–134. https://doi.org/10.1016/j.jrurstud.2011.10.001

Meyer, T. (2022). Starting-up alternative food systems. Understanding the potential of value-based supply chain startups to localize the food system in Germany through a multi-level perspective. *Master Thesis Series in Environmental Studies and Sustainability Science*. https://lup.lub.lu.se/student-papers/search/publication/9084704

Migliorini, P., & Wezel, A. (2017). Converging and diverging principles and practices of organic agriculture regulations and agroecology. A review. *Agronomy for Sustainable Development, 37*(6). https://doi.org/10.1007/s13593-017-0472-4

Milestad, R., Kummer, S., & Hirner, P. (2017). Does scale matter? Investigating the growth of a local organic box scheme in Austria. *Journal of Rural Studies, 54*, 304–313. https://doi.org/10.1016/j.jrurstud.2017.06.013

Penvern, S., Lamine, C., Derbez, F., Ollivier, G., Renier, L., Roche, R., & Tuscano, M. (2023). Addressing the diversity of visions of ecologization in research and in support to agroecological

transitions. *Agroecology and Sustainable Food Systems, 47*(9), 1403–1427. https://doi.org/10.1080/21683565.2023.2246395

Pitt, H., & Jones, M. (2016). Scaling up and out as a pathway for food system transitions. *Sustainability, 8*(10), 1025. https://doi.org/10.3390/su8101025

Rucabado-Palomar, T., & Cuéllar-Padilla, M. (2020). Short food supply chains for local food: A difficult path. *Renewable Agriculture and Food Systems, 35*(2), 182–191. https://doi.org/10.1017/S174217051800039X

Schneider, S., Salvate, N., & Cassol, A. (2016). Nested markets, food networks, and new pathways for rural development in Brazil. *Agriculture, 6*(4), 61. https://doi.org/10.3390/agriculture6040061

Schrode, A., Mueller, L. M., Wilke, A., Fesenfeld, L. P., & Ernst, J. *Transformation des Ernährungssystems: Grundlagen und Perspektiven.: Sozialökologische Transformation des Ernährungssystems -Sondierung umweltpolitischer Interventionsmöglichkeiten auf Basis aktueller Erkenntnisse der Transformationsforschung.*

Seyfang, G., & Haxeltine, A. (2012). Growing grassroots innovations: Exploring the role of community-based initiatives in governing sustainable energy transitions. *Environment and Planning C: Government and Policy, 30*(3), 381–400. https://doi.org/10.1068/c10222

Seyfang, G., & Smith, A. (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics, 16*(4), 584–603. https://doi.org/10.1080/09644010701419121

Smith, A., & Raven, R. (2012). What is protective space? Reconsidering niches in transitions to sustainability. *Research Policy, 41*(6), 1025–1036. https://doi.org/10.1016/j.respol.2011.12.012

Sutherland, L.-A., Darnhofer, I., & Wilson, G. A. (Eds.). (2015). Transition pathways towards sustainability in agriculture: Case studies from Europe. CABI. doi:https://doi.org/10.1079/9781780642192.0000.

van der Ploeg, J. D., Renting, H., Brunori, G., Knickel, K., Mannion, J., Marsden, T., de Roest, K., Sevilla-Guzmán, E., & Ventura, F. (2000). Rural development: From practices and policies towards theory. *Sociologia Ruralis, 40*(4), 391–408. https://doi.org/10.1111/1467-9523.00156

Vivero-Pol, J. (2017). Food as commons or commodity? Exploring the links between normative valuations and Agency in Food Transition. *Sustainability, 9*(3), 442. https://doi.org/10.3390/su9030442

Wezel, A., & Gkisakis, V. *(2023). Mapping the development of agroecology in Europa: Country reports series. Volume 1* (No. 1).

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