



## Research article

# Family farming in climate change: Strategies for resilient and sustainable food systems

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## ABSTRACT

Family farming plays a pivotal role in ensuring household food security and bolstering the resilience of food systems against climate change. Traditional agricultural practices are evolving into context-specific, climate-resilient systems such as family farming, homestead gardening, and urban agriculture. This study examines the ways in which family farming can foster climate-resilient food systems amidst climate vulnerabilities. A systematic literature review spanning the past 22 years was undertaken to develop a conceptual framework. From this review, 37 pertinent documents were identified, leading to the creation of a context-specific, climate-resilient food system framework. The research posits that family farming facilitates easy access to food and nutrition by capitalizing on family-sourced land, labor, and capital, and by securing access to technology and markets. Each facet of family farming is intricately linked with sustainability principles. Local adaptation strategies employed by climate-vulnerable households can diminish their vulnerability and augment their adaptive, absorptive, and transformative capacities, enabling them to establish a climate-resilient food system. The research further reveals that farming families employ a myriad of strategies to fortify their food systems. These include crop diversification, adjusting planting times, cultivating high-value crops and fish, planting fruit trees, rearing poultry and livestock, and leveraging their land, labor, and resources—including their homesteads—to access food and nutrition. This study endorses the climate-resilient family farming framework and offers multiple metrics for assessing the resilience of family farming in developing countries.

## 1. Introduction

Research on the impact of climate change on agriculture has been steadily intensifying. Small farms globally play a significant role in family subsistence, food provision, and local trade, making up over 80% of rural landscapes [1]. Within this setting, family farming's contributions to local development—such as ensuring a nutritious food supply, generating income, and conserving soil, water, and biodiversity—are undeniable [2,3]. The multifaceted nature of family farming is recognized not only as a lifestyle but also for its agricultural diversity, historical importance, and traditions [3]. These characteristics have garnered increased attention due to the challenges and changes induced by climate change. The heightened focus on potential shifts affecting family farming's resilience arises from the understanding that climate change disproportionately impacts the most vulnerable populations [4].

The relationship between family farming and sustainable development is progressively acknowledged as a fundamental element in the pursuit of the Sustainable Development Goals (SDGs). Family farms, which are frequently recognized for their multifunctional

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attributes, assume a crucial role in not only ensuring food security and nutrition but also in the effective management of natural resources, preservation of the environment, and establishment of sustainable livelihoods. Consequently, they make significant contributions towards the attainment of various SDGs, including but not limited to SDG 2 (zero hunger), SDG 6 (clean water and sanitation), SDG 8 (decent work and economic growth), SDG 10 (reduced inequality), and SDG 15 (life on land). Family farming is the foundation of more effective and sustainable agri-food systems [5]. Family agriculture, where a household merges family, farming, and commercial activities [6], remains the cornerstone of global agriculture. There's a prevailing belief that small family farms are more environmentally sustainable than their larger, corporate counterparts. These smaller farms are often seen as more diverse, employing traditional methods, conserving various land features, and planning for the long term, often with the intention of passing a well-maintained farm to the next generation [7]. The dominance of family-based farming operations, constituting over 98%, presents numerous challenges, especially given the ever-increasing demand for food, jobs, and ecosystem services [8]. The adaptability of family farms to economic and climatic shifts has been highlighted [9], as has their role in job creation and local economic stimulation. Family farming is acknowledged as a crucial element of climate-resilient food systems, providing a method for food production, championing local and sustainable food systems, and sustaining millions globally [10].

This research introduces a model to enhance sustainability and resilience in family farming, considering climate sensitivities. Our framework seeks to guide the evolution of climate-resilient agricultural systems, empowering family farms to adapt to and counteract climate change effects. Smallholder family farms, dependent on rainfall and other natural resources, are particularly susceptible to climate change [11]. Climate change disrupts precipitation patterns, exacerbates droughts and floods, and alters temperature norms, impacting crop yields, soil health, and water availability.

Beyond crop production, climate change has broader implications for family farming [12]. It affects the quantity and quality of vital resources like biodiversity, land, and water [13]. Smallholder farmers, dependent on these resources, face threats to their food sources. Moreover, climate change can exacerbate existing socio-economic disparities, leading to food insecurity, malnutrition, and increased poverty.

Family farming is recognized as an integral part of climate-resilient agricultural systems. Globally, especially in rural regions, millions derive their livelihood from family farming [14]. It offers a food production strategy often rooted in local knowledge and eco-friendly farming techniques. Family farmers can also play a significant role in establishing regional and sustainable food systems, enhancing the environmental sustainability of food production and distribution [15]. Family farming is a widespread practice that may be observed globally, but its expression is strongly influenced by specific geographical circumstances, which are influenced by distinct economic, cultural, environmental, and social elements. The acknowledgment of the variances in family farming practices across different locations is of utmost importance, as it significantly impacts the implementation and efficacy of climate adaptation measures. Family farming serves as a fundamental pillar of the local economy and culture in certain regions, whilst in other locations, it constitutes a component of a broader and more varied economic framework. Furthermore, family farms can aid in climate change adaptation and mitigation. Typically, family farming encompasses diverse agricultural and livestock production methods, potentially increasing resilience against climate change effects. The efforts of family farmers are also vital in maintaining soil health and biodiversity, potentially offsetting some of climate change's adverse effects [16]. Consequently, this research adopts a nuanced perspective, taking into account the distinct regional characteristics that influence the implementation of family farming and the necessary adaptive strategies to foster climate resilience.

Although there have been many research on family farming [17–20] and climate-resilient food systems [21–25], gaps remain in understanding how family farming can bolster climate-resilient food systems amidst climate vulnerabilities. Few studies have delved into how family farming can enhance climate resilience [3], especially in regions prone to climate change effects like droughts, floods, and extreme weather events. Some research has explored family farming's role in promoting sustainable agriculture [26–28] and food security [29–31], but there's limited insight into the specific strategies family farmers can employ to foster climate resilience. Addressing the research gap, this study presents a unique analytical framework that delineates the function of family farming in climate-resilient food systems, apart from the broader discourses found in existing literature such as Nepomoceno and Carniatio [3]. The paradigm presented here is based on a comprehensive examination of existing practices and is further enhanced by recent empirical findings that highlight the resilience and sustainability of family farming in various ecological and socio-economic settings.

This study seeks to answer: a) How is the concept of climate-resilient food systems depicted in existing literature? b) How can family farming bolster climate-resilient food systems amidst climate vulnerabilities? And c) Which family farming practices have empirically shown to support resilience and sustainability in the food system? By addressing these questions, we aim to deepen the understanding of family farming's role in fostering climate-resilient food systems and highlight strategies to aid family farmers in building resilience and sustainability in their food systems amidst climate vulnerabilities.

This research advances to the academic discourse surrounding sustainable agriculture by introducing a conceptual framework that assesses the capacity of family farming to adapt within food systems that are resilient to climate change. In contrast to previous studies, this research incorporates agronomic, meteorological, and socio-economic viewpoints to present a comprehensive examination of family farming practices in diverse geographical areas. This study makes a valuable contribution to the existing body of literature by establishing a connection between family farming and the promotion of SDGs. Additionally, it puts forth specific policy interventions that highlight the distinct role of family farms in strengthening food security in the face of climate-related difficulties.

To tackle relevant challenges, we propose a model to enhance sustainability and resilience in family farming within the context of climate vulnerabilities. Our framework offers a holistic approach to bolstering sustainability and resilience in vulnerable family farming scenarios. It underscores the importance of melding traditional agricultural practices with context-specific, climate-resilient strategies to ensure food security and elevate the living standards of vulnerable communities. This model facilitates the evaluation of family farming's promotion of climate-resilient food systems by providing indicators for each component. It adds to the burgeoning

knowledge on climate-resilient food systems, guiding policymakers, practitioners, and scholars in championing resilient and sustainable agricultural production systems in high-risk settings.

The structure of this article is as follows: The subsequent section briefly reviews research on climate-resilient food systems, emphasizing family farming's significance and challenges in vulnerable settings. We then delve into the methodology, which includes an exhaustive literature review, used to craft the framework. The results are presented in the fourth section, followed by discussions and conclusions in the fifth and sixth sections, respectively.

## 2. Overview of climate-resilient food systems

The increasing effects of climate change on food production and the well-being of vulnerable communities have heightened interest in climate-resilient food systems (Schipanski et al., 2016; Toth et al., 2016). Family farming, typified by small-scale, subsistence-focused agriculture with a profound emphasis on social and cultural values, is seen as a pivotal element in bolstering climate-resilient food systems in numerous developing nations [32]. Its significance lies in its potential to offer a diverse range of nutrient-rich foods, generate employment opportunities, bolster biodiversity and ecosystem services, and enhance local food sovereignty [33]. Family farming has a vital role in both adapting to and reducing the effects of climate change through the implementation of sustainable land management techniques, the diversification of crop and livestock production, and the utilization of local resources and expertise [34]. Nevertheless, family farming in socioeconomically disadvantaged environments encounters a multitude of obstacles, such as restricted availability of land, water, and essential resources, insufficient infrastructure and services, and a scarcity of technical expertise and market entry opportunities [35]. The occurrence and severity of extreme weather events, such as droughts and floods, might be intensified by climate change. Additionally, climate warming can facilitate the proliferation of pests and illnesses [36]. The aforementioned difficulties pose a significant threat to the resilience and economic viability of family farming, as well as the food systems that rely on them.

In light of these issues, there has been a surge in scholarly work dedicated to examining the progression of climate-resilient food systems and the significance of family farming in achieving this objective [25]. This study highlights the significance of utilizing context-specific, integrated methodologies that consider the social, economic, and environmental variables that impact the sustainability and resilience of family farming (Fig. 1).

Fostering climate-resilient food systems requires the adoption of sustainable land management techniques, such as conservation agriculture [37], agroforestry [38], and soil and water conservation [39]. These practices may improve water availability and quality, decrease soil erosion, and raise soil fertility, increasing family farming's productivity and adaptability [40]. Another pivotal approach is agricultural diversification, which entails growing a variety of crops with distinct characteristics and functions. Such diversification can bolster soil health, reduce pest and disease incidence, enhance the nutritional diversity of produced food, and fortify food security and resilience [41]. The inclusion of livestock and poultry can also contribute to climate-adaptable food systems by providing additional sources of income and nutrition, enhancing soil fertility through manure, and offering alternative income streams [42]. Sustainable methods of managing livestock and poultry, such as rotational grazing and integrated pest control, can mitigate the environmental impacts of animal production while also enhancing productivity and resilience [43]. Craparo et al. [44] present a persuasive body of evidence supporting the incorporation of Circular Economy (CE) ideas into agricultural practices. This integration is crucial in promoting climate resilience within the context of family farming. The research emphasizes the importance of implementing sustainable and regenerative farming practices, especially in places that lack widespread adoption of such practices. This is crucial for attaining the goals outlined in SDG 2 and establishing resilient food systems. Homestead horticulture and fruit tree farming are also crucial to climate-resilient food systems, especially in peri-urban and urban areas with limited space [45]. Urban landscapes may become more beautiful and diverse due to these practices, which may contribute to people's food and revenue sources [21].

The resilience and sustainability of family farming depend on access to markets, technology, and financial services [46]. Financial

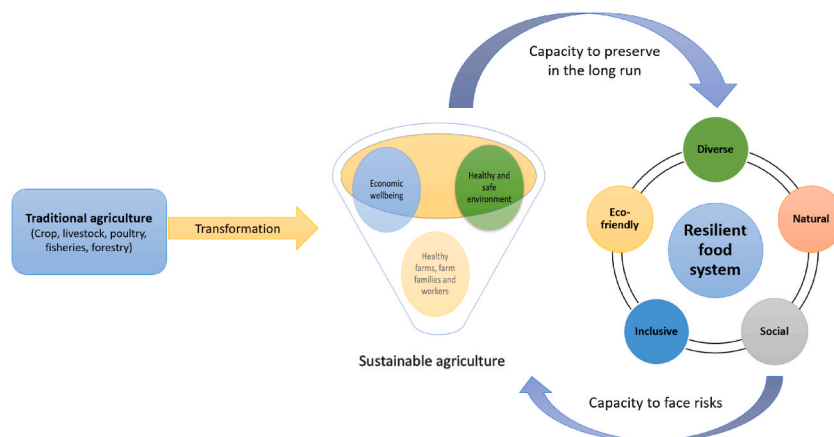


Fig. 1. Agricultural transformation towards a resilient food system.

services and markets can furnish resources and incentives for investment and innovation. Yet, formidable barriers persist in harnessing the full potential of family farming within climate-resilient agricultural frameworks. These barriers encompass inadequate infrastructural and policy frameworks, scarcity of resources and services, and the enduring ramifications of inequality and poverty. A collaborative approach, involving farmers, policymakers, researchers, and civil society organizations, is imperative to address these challenges [47]. Overall, research on climate-resilient food systems consistently underscores the centrality of family farming in fostering sustainability and resilience in adverse conditions [48]. Key strategies to achieve this goal encompass adopting sustainable land management practices, diversifying the agricultural sector, engaging in livestock and poultry farming, practicing homestead gardening, and ensuring access to technology, markets, and financial services.

### 3. Materials and methods

#### 3.1. Research protocol

A systematic literature review was undertaken according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards to create a conceptual framework for fostering sustainability and resilience in family farming in precarious settings [49]. The PRISMA criteria were chosen because of the rigor and openness with which they approach systematic literature reviews; both lessen the possibility of bias and increase confidence in the study's results and their capacity to be replicated. A research protocol was developed to guide the systematic literature review (Table 1).

#### 3.2. Search strategy

A thorough search was conducted in four electronic databases, including Web of Science, Scopus, Science Direct, and Google Scholar. Family farming, climate-resilient food systems, sustainability, and vulnerable contexts were the keywords used to search for studies published between January 2001 and April 2023. The search strategy was improved by employing Boolean operators, such as "AND" and "OR," and adding additional keywords as search criteria.

#### 3.3. Inclusion criteria

The inclusion criteria for this study consisted of articles that met the following conditions: (1) peer-reviewed articles published in English between January 2001 and April 2023, (2) articles that focused on topics such as family farming, climate-resilient food systems, sustainability, and disadvantaged contexts, and (3) empirical data-based articles focused on family farming in vulnerable contexts.

#### 3.4. Exclusion criteria

Research studies that did not meet the inclusion requirements, were not originally published in English, had nothing to do with family farming under precarious circumstances, or lacked access to the full texts of the publications were not considered. These were utilized to ensure that only easily available, relevant publications were included in the study.

#### 3.5. Screening process

The screening process was divided into two steps: screening titles and abstracts and screening the whole texts. To assess if the articles returned by the search method fit the inclusion requirements, two impartial examiners looked at the titles and abstracts of those publications. For a full-text review, only articles that fit the criteria for inclusion were selected.

**Table 1**

Research protocol.

Items	Description
Research question	How family farming can promote climate-resilient food systems in the context of climate vulnerability?
Search databases	Web of Science, Engineering village, Scopus, Google Scholar
Search keywords	Family farming, climate-resilient food systems, sustainability, vulnerable contexts
Search time frame	Articles published between January 2001 and April 2023.
Boolean operators	"AND", "OR"
Inclusion criteria	<ul style="list-style-type: none"> <li>Articles with peer review published in English between January 2001 and April 2023.</li> <li>Articles focusing on family farming, climate-resilient food systems, sustainability, and vulnerability contexts.</li> <li>Articles that present empirical data, case studies, or conceptual frameworks of family farming in vulnerability contexts.</li> </ul>
Exclusion criteria	<ul style="list-style-type: none"> <li>Articles that do not meet the inclusion criteria.</li> <li>Articles not initially published in English.</li> <li>Articles unrelated to family farming in fragile environments.</li> <li>Articles whose full texts are unavailable.</li> </ul>
Screening process	PRISMA checklists were followed for the screening process.
Data extraction	Pre-designed data extraction form including study design, methodology, population, intervention, outcome, and key findings.

### 3.6. Data synthesis and extraction

Information was taken from the chosen articles using a pre-designed data extraction form. The study's methodology, population, intervention, results, and significant findings were all included on the data extraction form. The gathered information on family farming in vulnerable situations was examined using a thematic synthesis process to identify key themes and ideas. The concepts of family farming, its stakeholders, stressors, unique aspects and characteristics, and potential benefits were the major issues which extracted from selected documents. Besides, the relationship between family farming practices and sustainability dimensions are also emphasized during data extraction. A conceptual framework for encouraging sustainability and resilience in family farming in vulnerable environments was developed using the results of the systematic review of the literature.

### 3.7. Quality assessment and bias mitigation

A careful quality evaluation was done to ensure the robustness of the conclusions. Studies that did not match our methodological standards were excluded. Cross-referencing with international agricultural organization publications were performed to enrich the review and address potential biases.

## 4. Results

### 4.1. Document selection

In this study, we employed predefined document selection criteria. The process was delineated into four stages: identification, screening, eligibility, and inclusion (Fig. 2). In addition to the 329 documents initially sourced from various databases and search engines during the identification phase, six more papers were identified from reference lists. After excluding 184 papers during the screening phase based on their titles and abstracts, 335 papers remained for further evaluation. In the eligibility phase, 114 articles were excluded from consideration for a variety of reasons, such as the inaccessibility of the full text, the paper's lack of significance to the research question, or the paper's insufficient focus on family farming and resilient food systems. There were 151 papers left over for further review after the first screening procedure. During the final inclusion phase, 37 articles in total were selected for qualitative analysis (Table S1). Relevance, quality, and alignment with the study subject were among the factors used in the selection process. In order to identify important themes and patterns, the data that were taken from the selected publications were subjected to a thorough and meticulous analysis that included the steps of classifying, categorizing, and synthesizing the data. To ensure that only the best and most relevant papers were included in the final analysis, the document selection procedure was carried out rigorously and methodically. The aforementioned procedure encompassed a series of screening measures and evaluations to determine eligibility.

### 4.2. Concepts of family farming

The term "family farming" refers to a system in which members of the same family work together to manage and operate a farm, as well as other related enterprises such as forestry, fishing, pastoralism, and aquaculture [27]. Family farming is a method of production

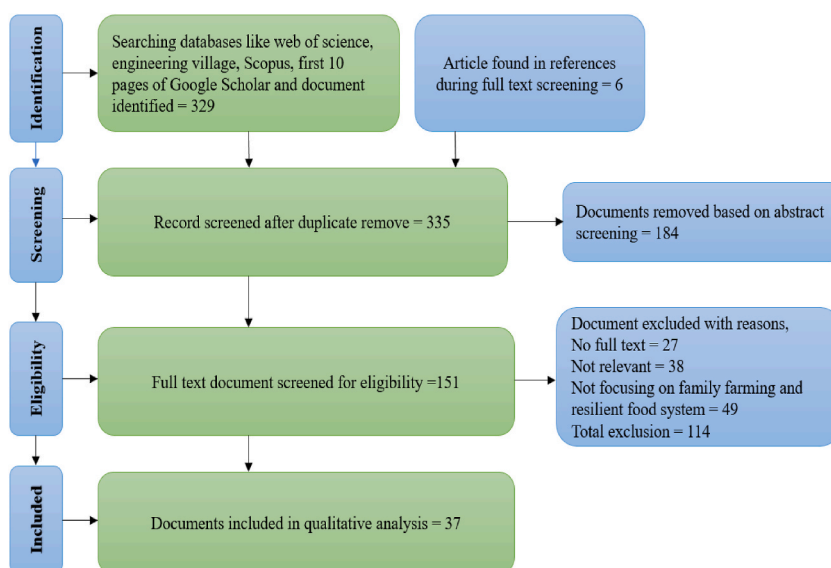


Fig. 2. Document selection by PRISMA approach.

in which members of the same family labor together to cultivate crops, raise livestock, tend flocks, and cultivate fish and other aquatic organisms. The family farm performs many important roles in society and the economy, including those related to the environment, reproduction, community, and culture (Table 2).

The concept of family farming has inherent diversity, as practices and meanings diverge considerably across various geographical areas [58]. According to the information presented in Table 2, the nature of family farming in any location is influenced by a multifaceted interaction among several factors, including local economic circumstances, cultural customs, environmental elements, and social dynamics. In certain geographical areas where agriculture serves as the foundation of the economy, family farming is frequently associated with modest, self-sustaining methods that are closely interconnected with cultural legacy and communal identity [18]. On the contrary, in regions characterized by a greater range of economic activities, family farming may adopt more commercially-oriented strategies, using new technologies and innovative business models [48]. The selection of crops and farming methods is additionally influenced by environmental factors, including climate and soil fertility [59]. Moreover, social institutions play a role in determining the allocation of tasks and the planning of generational transitions within agricultural households.

### 4.3. Components of resilient food systems

#### 4.3.1. Stakeholder level of family farming

Stakeholders are defined as any entities or individuals with a vested interest in family farming. Within the context of family farming, family members significantly influence agricultural practices and outcomes through their roles as stakeholders [60]. On a family farm, members from the same family collaborate and exchange ideas with other farmers and interested parties. Those engaged in the farm's daily operations and production, such as managers, workers, and consumers, are recognized as farm-level stakeholders [38]. Community-level stakeholders encompass individuals, community organizations, and local governments. Organizational-level stakeholders comprise NGOs, cooperatives, and other bodies that support and champion family farms. At the policy/enabling environment level, stakeholders include governmental bodies, policymakers, and other groups tasked with formulating and implementing policies that impact family farming practices and results. Gaining a comprehensive understanding of all the key players in the family farming sector is essential for designing policies and programs that ensure its sustainability and monetary success (Table 3).

#### 4.3.2. Key stressors

Family farms face pressures not only from economic, environmental, social, and institutional factors but also from a myriad of other challenges [83]. The economic dimension is characterized by issues related to cost control and revenue generation. Potential economic stressors encompass low profit margins, restricted access to capital, and fluctuating markets. Environmental challenges, such as climate change, soil degradation, and natural disasters, jeopardize agricultural yields and livestock production, thereby imperiling the livelihoods of family farmers [17]. The social dimension encompasses labor dynamics, population trends, and human resource concerns. Inevitable demographic shifts in family farming, driven by factors like migration, urbanization, and an aging population, can disrupt this balance [84]. Additionally, limited access to essential services, including education and healthcare, can adversely affect the health and well-being of family farmers and their communities. From an institutional perspective, family farms are influenced by regulations, policies, and safety nets [80]. Inadequate or inefficient governmental policies, subpar legal frameworks, and a scarcity of technical support and outreach resources contribute to these institutional pressures. Recognizing and understanding these stressors is vital for devising effective interventions to assist family farmers, as these challenges can significantly influence the sustainability and

**Table 2**  
Summary of family farming concepts.

Sources	Time	Summary opinion
Errington and Gasson [50]	1994	Family farming is a method of agricultural production that relies on family members' labor and resources, with hired help only when there is a labor shortage.
Altieri et al. [51]	2012	Family farming is crucial to agroecological methods of food production, which emphasize ecological sustainability, social justice, and food sovereignty.
Rosset and Martínez-Torres [52]	2012	Movements for food sovereignty, which work to guarantee that people have control over their food systems and access to wholesome, culturally appropriate food, mainly depend on family farming.
Holt-Giménez and Altieri [53]	2013	Family farming is a diversified and dynamic agricultural paradigm that varies considerably among locations and cultures, but is often characterized by small-scale production for local markets, the utilization of family labor and resources, and a deep connection to the land and community.
Ploeg [1]	2014	Family farming is an agricultural practice that stresses regional and local markets, crop variety, and environmental stewardship while maintaining family ownership and control over the land and production methods. Van der Ploeg et al. (2014)
Lamine [48]	2015	A strong feeling of duty defines family farming, care toward the land, and the passing of knowledge and skills between generations.
Gliessman [54]	2016	Family farms may contribute significantly to overcoming the problems caused by climate change by promoting sustainable land use techniques, agroforestry, and low-input agriculture.
Lowder et al. [55]	2016	For millions of small-scale farmers worldwide, particularly in low-income and rural regions, family farming is an essential source of income and food security.
Contzen and Forney [56]	2017	Family farming is often cited as the basis of stronger, more sustainable agri-food systems.
FAO [57]	2019	Family farming is crucial for reducing poverty, maintaining food security, and advancing rural development, particularly in emerging countries.

**Table 3**  
Stakeholder level of family farming.

Stakeholder level	Required qualities/stakeholders	Sources
Individual	Knowledge	[61,62]
	Attitude	[63,63]
	Behavior	[64,65]
Interpersonal	Families	[66,67]
	Friends and relatives	[68]
	Social networks	[11,69]
Farm	Business enterprise	[46,70]
	Environmental issues	[48,71]
Community level	Relationship among organizations	[72,73]
	Relationship among people	[7,74]
Organization level	Government organizations (GOs)	[35,75,76]
	Non-government organizations (NGOs)	[60,75]
	Voluntary organizations	[77,78]
	Social institutions	[79,80]
Policy/enabling environment	Local level	[17,81]
	State level	[43,82]
	National level	[35,55]

profitability of family farming systems (Table 4).

#### 4.3.3. Unique aspects of a family farm

Family farming possesses several unique characteristics that distinguish it from other agricultural production methods. One of the most defining features of family farming is its reliance on family labor for both farm management and operations. Typically, the farm is owned and managed by the family, intertwining the family's identity closely with the farm. Another hallmark of family farming is its tendency to operate on smaller landholdings. The intimate scale of family farming fosters intergenerational ties, often with multiple generations of family members coexisting and collaborating on the farm. Beyond labor, family members often assume diverse roles in both farm production and administration, further emphasizing the social and familial bonds that render family farming distinct. The success of family farming hinges on local knowledge and sustainable practices, positioning it as both a viable enterprise and a means of subsistence. Moreover, family farming places a premium on food security and livelihood. In essence, family farming is a specialized form of agricultural production characterized by deep familial ties to the farm, smaller landholdings, reliance on family labor, and an emphasis on sustainability and local expertise (Table 5).

#### 4.3.4. Potential benefits of a family farm

Family farming offers numerous benefits, both to the broader society and at the individual farm level. One notable advantage of family farming is the enhancement of farm safety, as family members typically prioritize safe working conditions and practices [97]. With its diversified production systems and reliance on local knowledge, family farming serves as a mechanism for managing agricultural risks, mitigating threats posed by market fluctuations, climate change, and other factors. Another significant benefit of family farming is the greater control it affords over food production, processing, and distribution [101]. This control not only serves as a consistent income source but also aids families in achieving financial stability. Transition planning in family farming facilitates the transfer of knowledge, skills, and land to succeeding generations. Moreover, family farming provides opportunities for education and skill development, potentially aiding the personal growth of younger members. Family farmers often supply their families and communities with fresh, nutrient-rich produce, hinting at another potential advantage of family farming: improved nutrition and health management [95]. Beyond these benefits, family farming can drive sustainable development and stand as a pillar of social and cultural identity, contributing holistically to community well-being (Table 6).

#### 4.4. Sustainability dimensions of family farming

Family farming plays a multifaceted role in advancing sustainability. Economically, family farming is pivotal as it sustains rural livelihoods and bolsters rural economies [59]. From an environmental perspective, family farming champions sustainable agricultural

**Table 4**  
Key stressors.

Key dimensions	Main stressors	Sources
Economic dimension	Production uncertainties	[4,17]
	Market uncertainties	[85,86]
Environmental dimension	Weather uncertainties	[65,87]
Social dimension	Family complexities	[8,88]
	Social complexities	[89]
Institutional dimension	Challenges to access to institutional services	[80,90]

**Table 5**  
Unique aspects of a family farm.

Unique aspects	Main stressors	Sources
Family labor	<ul style="list-style-type: none"> <li>• Accidents and injuries sustained on the job.</li> <li>• Physical fatigue and distress.</li> </ul>	[64,91] [18]
Farm managed by household and family	<ul style="list-style-type: none"> <li>• Problems with decision-making</li> <li>• Challenges in expanding up production</li> </ul>	[56,92] [93]
Small farm size	<ul style="list-style-type: none"> <li>• Limited resources and land availability</li> <li>• Succession planning</li> </ul>	[72,94] [7,65]
Inter-generational linkage Social and family ties	<ul style="list-style-type: none"> <li>• Transition planning and knowledge transmission</li> <li>• Striking a work-family balance</li> <li>• Interpersonal disagreements</li> </ul>	[4,7] [18,95] [90]
Subsistence/profitable business	<ul style="list-style-type: none"> <li>• Limited availability of contemporary technology and innovation</li> <li>• Adaptation to variable environmental conditions</li> </ul>	[3,79] [96]
Local knowledge and sustainable practices	<ul style="list-style-type: none"> <li>• Financial security and income stability</li> <li>• Market volatility and price fluctuations</li> <li>• Natural resource constraints and conservation</li> <li>• Balancing environmental impact with productivity</li> </ul>	[97] [98,99] [100] [90]
Ensuring food security Livelihood security	<ul style="list-style-type: none"> <li>• External perturbations and disturbances</li> <li>• Stability of the economy and diversification of income</li> </ul>	[101] [102]

**Table 6**  
Potential benefits of a family farm.

Potential benefits	Details	References
Farm safety	<ul style="list-style-type: none"> <li>• Increased safety precautions and procedures due to family members managing and operating the farm.</li> <li>• A greater sense of awareness and responsibility for maintaining safe working conditions.</li> </ul>	[84,103] [104]
Agricultural risk management	<ul style="list-style-type: none"> <li>• Due to intimate family engagement in day-to-day agricultural operations, family members have knowledge and experience managing climatic unpredictability, market changes, and other hazards.</li> <li>• Using sustainable methods as a risk management tactic.</li> </ul>	[105] [3,87]
Food safety	<ul style="list-style-type: none"> <li>• Due to family participation, more control over the farming operations, including distribution and processing.</li> <li>• The use of food safety procedures and adherence to laws.</li> </ul>	[82] [106]
Risk management of family	<ul style="list-style-type: none"> <li>• A steady source of income and support for the family, ensuring financial security during economic uncertainty.</li> <li>• The possibility of generating various streams of revenue via agriculture.</li> </ul>	[3,105]
Financial well-being	<ul style="list-style-type: none"> <li>• Economic stability and the capacity to generate money through family farming.</li> <li>• Possibilities for revenue growth and company development via environmentally friendly agricultural methods.</li> </ul>	[90,107] [33]
Transition planning	<ul style="list-style-type: none"> <li>• Generational knowledge and skill transfer ensure the family farm's continuation and durability.</li> <li>• A seamless transition of farm ownership and management between generations.</li> </ul>	[4,7]
Youth development	<ul style="list-style-type: none"> <li>• Possibilities for learning, developing skills, and gaining first-hand knowledge of agricultural management on the family farm</li> </ul>	[3,27]
Nutrition	<ul style="list-style-type: none"> <li>• The production of a variety of wholesome food alternatives as a result of family farms' extensive use of various animals and crops.</li> <li>• Better access for the family and neighborhood to wholesome meals.</li> </ul>	[96,101] [21]
Health management	<ul style="list-style-type: none"> <li>• Lessening of chemical and pesticide exposure on family farms thanks to sustainable agricultural methods.</li> <li>• Better health results as a result of consuming wholesome, fresh food that is grown on a farm.</li> </ul>	[108] [109]
Healthy community	<ul style="list-style-type: none"> <li>• Social and cultural identity maintained by family farms' use of regional customs and agricultural methods.</li> <li>• Promoting resilience and sustainable development within the community.</li> </ul>	[18] [3]

practices such as agroforestry, conservation agriculture, and integrated pest management. These practices mitigate the negative environmental impacts of agriculture and aid in the conservation of natural resources [7]. The environmental constraints encountered by family farms exhibit considerable heterogeneity, manifesting divergent characteristics across various geographical areas [74]. For instance, the problem of water shortages may provide a significant challenge in dry locations, hence requiring the implementation of inventive approaches to water management. In contrast, other areas may face issues such as soil degradation or the recurrent incidence of extreme weather phenomena. The presence of regional disparities highlights the importance of implementing sustainable strategies

**Table 7**  
Sustainability dimensions of family farming.

Sustainability dimensions	Indicators	References
Economic dimension	<ul style="list-style-type: none"> <li>• Income generating activities</li> <li>• Economic well-being</li> </ul>	[86] [18,59]
Environmental dimension	<ul style="list-style-type: none"> <li>• Healthy and safe environment</li> <li>• Building adaptive capacity</li> <li>• Green space</li> </ul>	[101,110] [11,111] [21,78]
Social dimension	<ul style="list-style-type: none"> <li>• Healthy farmers</li> <li>• Healthy farm families</li> <li>• Healthy workers</li> </ul>	[18,100] [95,112] [100,113]



that are tailored to the individual setting. Socially, family farming fosters community cohesion, safeguards cultural heritage, and promotes social equity, especially for often marginalized groups like women and youth. This aligns with the social dimension of sustainability. Furthermore, family farming enhances food sovereignty and security by ensuring communities have consistent access to nutritious food. Given its profound contributions across various facets of sustainability, family farming should be fervently advocated for and preserved as a linchpin in sustainable development strategies (Table 7).

### 5. Discussion

The present study offers a comprehensive examination of the contribution of family farming in building food systems that are robust to climate change. This research indicates that family farms include distinct qualities that make them particularly well-suited for the adoption and advantageous outcomes of sustainable practices. These attributes include the cultivation of diverse crops and livestock, as well as a profound bond with the land and local community [114]. The aforementioned results are consistent with and build upon the existing body of literature that emphasizes the diverse roles of family farming in fostering both environmental conservation and socio-economic progress [53,64].

In contrast to previous investigations, our study sheds light on the capacity of family farming to make a meaningful contribution towards the attainment of the SDGs [115]. Specifically, This research showcases the ability of family farms to effectively adjust to and alleviate the consequences of climate change [25]. The significance of this contribution is heightened due to the pressing necessity for sustainable agriculture methods in light of the global climate issues [1,53].

#### 5.1. Concepts of family farming

Family farming is predominantly governed by a family and heavily relies on family labor. It encompasses various roles on the family farm, including economic, environmental, reproductive, social, and cultural functions [65]. The family is integral to the farm’s operation and management, as the two are intricately linked and evolve in tandem. Family farming extends beyond mere crop production, encompassing forestry, fisheries, pastoral activities, and aquaculture, highlighting the significance of these agricultural endeavors for household income and food consumption [54]. In recent years, family farming has garnered increased attention due to its pivotal role in championing sustainable agriculture and rural development. The success of family farms is instrumental in preserving and enhancing rural livelihoods and in ensuring environmental conservation through sustainable land practices.

Numerous benefits arise from emphasizing family farming, including a more equitable distribution of resources, increased incomes for rural households, and the preservation of time-honored farming techniques. Such a focus also fosters resource efficiency, biodiversity, and environmentally responsible agriculture, especially among land-owning farmers. Additionally, family farming propels rural development by generating employment, reducing poverty, and invigorating local economies. However, despite its evident advantages, family farming confronts challenges like intensified competition from industrial agriculture and evolving consumer preferences. Many family farmers, due to limited resources, technology, and market insights, find themselves less competitive and often produce on a smaller scale [53]. The perception of farming as mere subsistence rather than a viable business further constrains the potential for growth in family farming. Proposed policy interventions to address these challenges include recognizing family farming as a significant economic activity, endorsing sustainable agricultural practices, and offering support services like credit, extension services, and market access. Such initiatives can empower family farmers to enhance their productivity and competitiveness while safeguarding the environment and strengthening rural communities.

In essence, family farming is indispensable for the sustained success of agriculture and rural development. It recognizes the multifaceted roles of the family in farming, from preserving traditional agricultural knowledge to enabling higher rural incomes and promoting efficient natural resource utilization. Yet, challenges persist, including competition from large-scale commercial agriculture and limited access to finance and technology. Policy interventions can potentially address these issues, reinforcing the continued

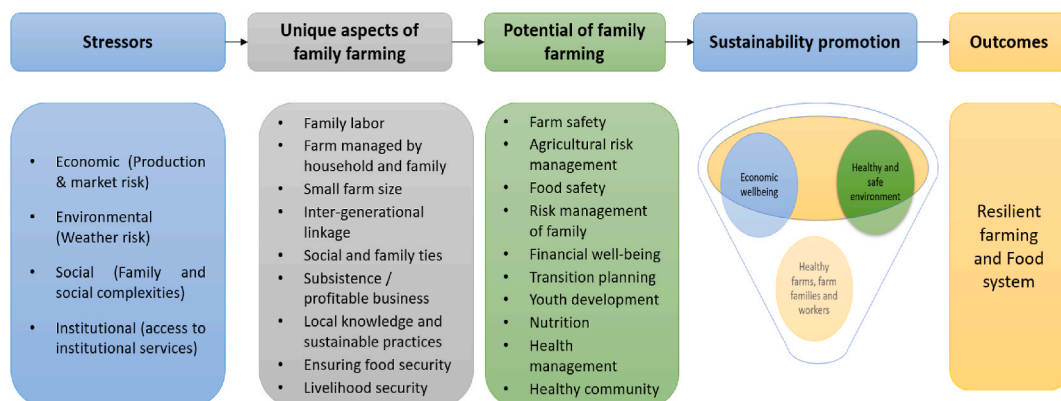


Fig. 3. Framework for a climate-resilient farming and food system.

relevance of family farming in the broader landscape of sustainable agriculture and rural development [1].

## 5.2. Framework for a context specific climate-resilient food system

In light of the emerging challenges posed by climate change, farmers are compelled to adapt their practices to ensure sustainable and resilient food production. A framework for a context-specific, climate-resilient food system has been delineated into five critical stages. The initial stage emphasizes the importance of devising effective adaptation strategies by identifying stressors and understanding their implications for agriculture. The second stage involves leveraging the unique attributes of a family farm to maximize strengths and mitigate weaknesses. The third stage underscores the potential contributions of family farms to enhancing climate resilience, such as promoting sustainable agriculture and augmenting biodiversity. Sustainable farming practices, including efficient water management and soil conservation, can fortify food production systems. The overarching objective is to cultivate agricultural and food systems robust enough to withstand climate change impacts, diminish community vulnerability, and guarantee food security for all. By employing this framework, farmers and community leaders can craft strategies tailored to address their distinct challenges (Fig. 3).

### 5.2.1. Stressors

Four primary stressors can impact climate-resilient food systems: economic, ecological, social, and institutional. "Economic stressors" refer to the financial uncertainties and challenges farmers face due to climate change, including commodity price fluctuations, crop losses, and increased input costs. Ecological stressors encompass the adverse effects of climate change on the environment, such as soil erosion, water scarcity, and biodiversity loss. Social stressors arise from global warming's societal impacts, including population migration, resource competition, and disruptions [17]. Institutional stressors, related to the governance of agriculture, include limited access to loans, inadequate infrastructure, and subpar extension services. While all these stressors are significant, institutional ones may be particularly challenging due to the potential delays in legislative changes taking effect [90]. Therefore, a comprehensive strategy for developing climate-resilient food systems should address all these stressors through various tactics, including legislative interventions, public awareness campaigns, and technological innovations [4].

### 5.2.2. The unique aspect of family farming for climate-resilient food system

Family farming represents a distinct form of agricultural production with significant potential to foster the development of climate-resilient food systems. A hallmark of family farming is its reliance on family labor. Managed with long-term vision and succession planning, family farms often employ sustainable agricultural practices like crop rotation and integrated pest control, enhancing soil health and minimizing environmental impacts. The primary actors in family farming are the family members who oversee all farm aspects [64]. This level of management ensures decisions prioritize the farm's long-term viability. Family farmers, having a vested interest in their land's health, are more inclined to adopt sustainable land use practices. This stewardship reduces the environmental impact of agricultural production and promotes efficient resource use. Additionally, the small scale of most family farms, coupled with their diverse crops and livestock, reduces the risk of crop failure due to weather or pests. Intergenerational relationships on family farms facilitate the transfer of sustainable agricultural knowledge and skills [79]. Moreover, the strong social and familial bonds inherent in family farming can be invaluable during crises. Recognizing family farming as both a subsistence activity and a viable business can lead to its expansion and growth. Overall, family farming offers numerous attributes conducive to a climate-resilient food system, including family labor, farm management by the family, small farm size, intergenerational ties, social and familial bonds, local expertise, sustainable practices, and a focus on food and livelihood security [96].

### 5.2.3. Potential benefits of family farming in climate resilient food system

Family farming offers numerous advantages to food systems aiming for climate resilience. One of its primary benefits is the enhanced safety it brings. Given that family members manage and operate these farms, they have a heightened sense of responsibility towards the farm's safety standards. They are more inclined to adopt safe work practices, utilize protective equipment, and handle machinery with care [84], thereby potentially reducing the risk of accidents.

One of the ways family farms contribute to climate-resilient food systems is by effectively managing agricultural risks. The hands-on involvement of family farmers, combined with their deep understanding of the environment, seasonal patterns, and crop cycles, allows them to adeptly manage crop diversification, soil conservation, and water management [3]. These sustainable agricultural practices can mitigate the impact of adverse weather conditions on their farms, reducing the risk of crop failure. Another critical aspect of climate-resilient food systems is ensuring food safety [82]. Family farmers, with their direct control over production and farm management, are more likely to use safe pesticides and herbicides, maintain high sanitation standards, and implement other food safety measures. This meticulous approach can translate to higher quality products for consumers.

Risk-sharing within the family is another way family farms can bolster food systems against the effects of climate change. Family farming provides members with a source of income and sustenance, enhancing their financial stability and reducing their vulnerability to economic downturns [90]. Moreover, it can serve as a safety net for family members during adversities, such as illness or unemployment. Financial stability is another advantage that family farming brings to climate-resilient agricultural systems. The nature of small-scale agriculture allows family farmers to have greater financial control. By adopting sustainable farming practices and efficient strategies, family farmers can reduce production costs and increase profitability. This financial stability can play a pivotal role in combating rural poverty and furthering sustainable development [33].

Transition planning is essential for climate-resilient agricultural systems in family farms [4]. Elderly family farmers need to prepare

for the eventual transition of the farm to the next generation [7]. Through family farming, younger members can acquire knowledge and skills from their more experienced counterparts, ensuring the farm's long-term viability and the family's continued prosperity.

#### 5.2.4. Sustainability for climate-resilient family farming and food system

**5.2.4.1. Economic dimension.** Family farming practices offer farmers both access to and the means to generate income. Techniques such as crop rotation, intercropping, relay cropping, crop diversification, and agroforestry can enhance crop yields, rejuvenate soil fertility, and mitigate losses from pests and diseases [86]. Consequently, these practices can augment farmers' revenues, reduce their reliance on external inputs like pesticides and fertilizers, and bolster their presence in local and global markets. Furthermore, sustainable family farming can foster the growth of small to medium-sized enterprises, providing employment opportunities, especially for women and youth, thereby invigorating local economies [18]. Moreover, it can mitigate risks associated with climate change, such as droughts, floods, and extreme weather events, enhancing the economic resilience of farming communities.

**5.2.4.2. Environmental dimension.** Sustainable family farming practices can play a pivotal role in curtailing environmental degradation and combatting climate change [65]. Approaches like agroforestry, conservation agriculture, and integrated pest management not only enhance biodiversity but also improve soil health and water conservation. Sustainable family farming can also curtail the use of chemical fertilizers and pesticides, mitigating their adverse effects on both the environment and human health [11]. Additionally, sustainable family farming can champion the adoption of renewable energy sources, such as solar and wind power, reducing dependence on fossil fuels. In essence, family farming practices empower farmers to judiciously utilize and conserve natural resources [39], thereby promoting environmental sustainability.

Moreover, it is important to recognize the significant impact of regional characteristics on environmental concerns that impact the practice of family farming. For example, the issue of water shortages may be a significant difficulty in dry locations, hence requiring the implementation of distinct conservation techniques. Conversely, places characterized by fertile soil profiles may face the problem of soil degradation resulting from intensive agricultural operations. Likewise, geographical areas susceptible to severe climatic phenomena such as storms or droughts necessitate customized strategies to safeguard the resilience of agricultural operations at the household level. The recognition of these varied regional problems is crucial in order to facilitate the formulation of specific climate adaption plans and the execution of sustainable agriculture practices that are tailored to the unique environmental conditions of each locality [116]. This study emphasizes the necessity of doing research and formulating policies that are tailored to individual regions, considering the distinct environmental, economic, and social circumstances of family farms. This approach is crucial for promoting agricultural systems that are genuinely sustainable and resilient [117].

**5.2.4.3. Social dimension.** Family farming is woven into the very fabric of rural communities, serving as a linchpin in their social structures. Among the myriad social benefits that family farming can usher in are elevated incomes, enhanced rural employment prospects, and a reduction in poverty [18]. Supporting family farming also aids in preserving agricultural traditions, which are paramount for maintaining cultural diversity and identity. By promoting sustainable family farming practices, farmers can bolster social cohesion and instill a sense of collective responsibility and stewardship for the environment [95].

The present discourse expands upon the dialogue regarding family farming and its relationship to climate resilience, delving into an in-depth examination of context-specific approaches that effectively promote the sustainability of food systems. In contrast to the more comprehensive theme investigation conducted by Nepomoceno and Carniatio [3], our research focuses on the examination of micro-level adaptations and their potential consequences for policy and practice. It offers practical insights that may be utilized by relevant stakeholders.

### 5.3. Policy recommendations for climate-resilient family farming

In order to enhance climate resilience within the context of family farming, it is imperative for policymakers to adopt a comprehensive approach encompassing several initiatives. Financial assistance mechanisms, including as subsidies and insurance programs, play a crucial role in facilitating farmers' adoption of resilient strategies and mitigating the adverse impacts of climate-induced losses. The allocation of resources towards agricultural research is of utmost importance in order to foster the development of pioneering farming methodologies and cultivate crop types that are well-adapted to the dynamic nature of climate change. The economic empowerment of family farmers can be facilitated by infrastructure improvements and market access measures, while their adaptive capacity can be enhanced through education and training programs. The implementation of policies that are customized to account for regional nuances, such as environmental factors and cultural traditions, will guarantee the efficacy and long-term viability of initiatives.

In addition, it is imperative that policies are designed to provide incentives for the adoption of environmentally sustainable techniques, such as organic farming and agroforestry, which have the potential to contribute significantly to both climate mitigation and adaptation efforts. Enhancing the legal frameworks pertaining to land and water rights will afford family farmers the necessary stability to engage in long-term investments. The facilitation of information exchange and collective action can be enhanced through community engagement and the establishment of farmer groups. In conclusion, it is imperative to prioritize the establishment of inclusive and equitable policies, with a specific focus on women, youth, and vulnerable populations. This is crucial in order to cultivate social resilience and guarantee that every individual within the community has the opportunity to actively participate in and reap the

rewards of climate-resilient agricultural methods.

## 6. Conclusion

This study delves into the potential of family farming in fostering climate-resilient food systems amidst climate vulnerabilities. It posits that family farming, by leveraging familial resources in land, labor, and capital, and by accessing technology and markets, can ensure food and sustenance. Each aspect of family farming is deeply intertwined with sustainability principles. Local adaptation measures, when adopted by climate-vulnerable households, can diminish their vulnerability and bolster their adaptive, absorptive, and transformative capacities, paving the way for a climate-resilient food system. The research further underscores the myriad strategies farming families deploy to fortify their food systems. These include crop diversification, adjustments in cropping seasons, cultivation of high-value crops and fish, fruit tree planting, poultry and livestock rearing, and the strategic utilization of their assets, including homesteads, to secure food and nutrition. This study endorses the framework for climate-resilient family farming and introduces several metrics to evaluate the resilience of family farming in developing countries. It accentuates the significance of family farming as an integral component of resilient and sustainable food systems in climate-sensitive scenarios, providing insights into harnessing family farming to achieve sustainability goals.

However, this study is not without its limitations. First, by focusing solely on English-language literature, potentially pertinent information from non-English sources was overlooked. Second, the exclusive reliance on electronic databases might have omitted relevant studies published in alternative outlets, such as gray literature. Third, the inclusion of papers with varied quality might have influenced the robustness of the study's conclusions. Lastly, as a systematic review, this study could not adequately focus the regional differences.

Drawing from this study's findings, future research endeavors may include doing comprehensive case studies in various regional contexts to examine the intricate effects of climate change on family farming and evaluate the efficacy of localized adaptation measures. Comparative assessments conducted across different locations have the potential to unveil optimal strategies and common obstacles, thereby enriching a global repository of knowledge that facilitates the formulation of focused policies and programs tailored to specific regions. The presence of regional differences highlights the importance of conducting research and formulating policies that are tailored to specific contexts, taking into account the distinct problems and opportunities associated with family farming in various geographical and cultural settings. Therefore, considering regional differences, future studies should also be conducted based on primary data in various regions and cultural settings. Longitudinal research would provide useful insights by establishing a temporal perspective on the sustainability of adaptation methods and the long-term impacts of policy initiatives. The active involvement of family farmers in collaborative processes, aimed at jointly developing and evaluating novel approaches, has the potential to provide enhanced and enduring results. This approach would prioritize the inclusion of individuals who are most impacted by climatic vulnerabilities, enabling their perspectives to be acknowledged and their expertise to be integrated into initiatives focused on enhancing resilience.

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## CRedit authorship contribution statement

**Kang Chao:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e28599>.

## References

- [1] J.D. van der Ploeg, Peasant-driven agricultural growth and food sovereignty, *J. Peasant Stud.* 41 (2014) 999–1030, <https://doi.org/10.1080/03066150.2013.876997>.

- [2] S. Schneider, V.F. Thies, C. Grisa, W. Belik, Potential of public purchases as markets for family farming: an analysis of Brazilian school feeding program between 2011 and 2014. <https://doi.org/10.1016/bs.af2s.2016.09.003>, 2016.
- [3] T.A.R. Nepomoceno, I. Carniatio, Correlations between climate resilience in family farming and sustainable rural development, *Ambio* 52 (2023) 1233–1247, <https://doi.org/10.1007/s13280-023-01848-x>.
- [4] I. Darnhofer, C. Lamine, A. Strauss, M. Navarrete, The resilience of family farms: towards a relational approach, *J. Rural Stud.* 44 (2016) 111–122, <https://doi.org/10.1016/j.jrurstud.2016.01.013>.
- [5] J. Worstell, J. Green, Eight qualities of resilient food systems: toward a sustainability/resilience index, *J. Agric. Food Syst. Community Dev.* 7 (2017) 1–19, <https://doi.org/10.5304/jafscd.2017.073.001>.
- [6] G.M. Alam, R. Shrestha, Promote sustainability of family farming for climate-resilient food systems in South Asia, in: *Reg. Action Plan to Implement UNDDF Achiev. SDGs South Asia*, 2021, pp. 82–100.
- [7] L. Holloway, G. Catney, A. Stockdale, R. Nelson, Sustainable family farming futures: exploring the challenges of family farm decision making through an emotional lens of 'belonging, Sustainability 13 (2021) 12271, <https://doi.org/10.3390/su132112271>.
- [8] B.E. Graeb, M.J. Chappell, H. Wittman, S. Ledermann, R.B. Kerr, B. Gemmill-Herren, The state of family farms in the world, *World Dev.* 87 (2016) 1–15, <https://doi.org/10.1016/j.worlddev.2015.05.012>.
- [9] L.T. Habtemariam, G. Abate Kassa, M. Gandorfer, Impact of climate change on farms in smallholder farming systems: yield impacts, economic implications and distributional effects, *Agric. Syst.* 152 (2017) 58–66, <https://doi.org/10.1016/j.agsy.2016.12.006>.
- [10] A. Devaux, J.P. Goffart, P. Kromann, J. Andrade-Piedra, V. Polar, G. Hareau, The potato of the future: opportunities and challenges in sustainable agri-food systems, *Potato Res.* 64 (2021) 681–720, <https://doi.org/10.1007/s11540-021-09501-4>.
- [11] B. Bulla, T. Steelman, Farming through change: using photovoice to explore climate change on small family farms, *Agroecol. Sustain. Food Syst.* 40 (2016) 1106–1132, <https://doi.org/10.1080/21683565.2016.1225623>.
- [12] M. Guth, S. Stepien, K. Smędzik-Ambroży, A. Matuszczak, Is small beautiful? Technical efficiency and environmental sustainability of small-scale family farms under the conditions of agricultural policy support, *J. Rural Stud.* 89 (2022) 235–247, <https://doi.org/10.1016/j.jrurstud.2021.11.026>.
- [13] W. Adzawla, S. Kudadze, A.R. Mohammed, I.I. Ibrahim, Climate perceptions, farmers' willingness-to-insure farms and resilience to climate change in Northern region, Ghana, *Environ. Dev. Pol.* 32 (2019) 1–12, <https://doi.org/10.1016/j.envdev.2019.100466>.
- [14] L. Roudart, B. Dave, Land policy, family farms, food production and livelihoods in the Office du Niger area, Mali, *Land Use Pol.* 60 (2017) 313–323, <https://doi.org/10.1016/j.landusepol.2016.10.029>.
- [15] *EuropAfrica, Family Farmers for Sustainable Food Systems: a Synthesis of Reports by African Farmers' Regional Networks on Models of Food Production, Consumption and Markets*, 2013.
- [16] A. Wezel, B.G. Herren, R.B. Kerr, E. Barrios, A.L.R. Gonçalves, F. Sinclair, Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review, *Agron. Sustain. Dev.* 40 (2020) 40, <https://doi.org/10.1007/s13593-020-00646-z>.
- [17] L.A. de O. Fernandes, P.J. Woodhouse, Family farm sustainability in southern Brazil: an application of agri-environmental indicators, *Ecol. Econ.* 66 (2008) 243–257, <https://doi.org/10.1016/j.ecolecon.2008.01.027>.
- [18] C. McShane, F. Quirk, A. Swinbourne, The role of farming families in future economic and community sustainability, *Int. J. Soc. Sustain. Econ. Soc. Cult. Context* 8 (2013) 111–133, <https://doi.org/10.18848/2325-1115/cgp/v08i03/55197>.
- [19] G. Medina, C. Almeida, E. Novaes, J. Godar, B. Pokorny, Development conditions for family farming: lessons from Brazil, *World Dev.* 74 (2015) 386–396, <https://doi.org/10.1016/j.worlddev.2015.05.023>.
- [20] J. Wilson, A. Tonner, Doing family: the constructed meanings of family in family farms, *J. Rural Stud.* 78 (2020) 245–253, <https://doi.org/10.1016/j.jrurstud.2020.06.002>.
- [21] A. Toth, S. Rendall, F. Reitsma, Resilient food systems: a qualitative tool for measuring food resilience, *Urban Ecosyst.* 19 (2016) 19–43, <https://doi.org/10.1007/s11252-015-0489-x>.
- [22] M.E. Schipanski, G.K. MacDonald, S. Rosenzweig, M.J. Chappell, E.M. Bennett, R.B. Kerr, J. Blesh, T. Crews, L. Drinkwater, J.G. Lundgren, C. Schnarr, Reclaiming resilient food systems, *Bioscience* 66 (2016) 600–610, <https://doi.org/10.1093/biosci/biw052>.
- [23] S. Klassen, S. Murphy, Equity as both a means and an end: lessons for resilient food systems from COVID-19, *World Dev.* 136 (2020) 105104, <https://doi.org/10.1016/j.worlddev.2020.105104>.
- [24] A. Fantini, Urban and peri-urban agriculture as a strategy for creating more sustainable and resilient urban food systems and facing socio-environmental emergencies, *Agroecol. Sustain. Food Syst.* 47 (2023) 47–71, <https://doi.org/10.1080/21683565.2022.2127044>.
- [25] V.J. Little, M. Holmlund, P. Polska, M. Naidu, Towards more resilient food production systems: implanting sustainability-oriented innovation, *J. Clean. Prod.* 385 (2023) 135708, <https://doi.org/10.1016/j.jclepro.2022.135708>.
- [26] A. Hailelassie, P. Craufurd, R. Thiagarajah, S. Kumar, A. Whitbread, A. Rathor, M. Blummel, P. Ericsson, K.R. Kakumanu, Empirical evaluation of sustainability of divergent farms in the dryland farming systems of India, *Ecol. Indic.* 60 (2016) 710–723, <https://doi.org/10.1016/j.ecolind.2015.08.014>.
- [27] W. Ortiz, U. Vilsmaier, Á. Acevedo Osorio, The diffusion of sustainable family farming practices in Colombia: an emerging sociotechnical niche? *Sustain. Sci.* 13 (2018) 829–847, <https://doi.org/10.1007/s11625-017-0493-6>.
- [28] L. Thanh Hai, Q.B. Tran, V.T. Tra, T.P.T. Nguyen, T.N. Le, H. Schnitzer, G. Braunegg, S. Le, C.T. Hoang, X.C. Nguyen, V.H. Nguyen, W. Peng, S.Y. Kim, S.S. Lam, Q. Van Le, Integrated farming system producing zero emissions and sustainable livelihood for small-scale cattle farms: case study in the Mekong Delta, Vietnam, *Environ. Pollut.* 265 (2020), <https://doi.org/10.1016/j.envpol.2020.114853>.
- [29] A. de la Peña García, S.A. Zimmermann, A.A. Eleuterio, Food supply chains, family farming, and food policies under the COVID-19 pandemic in a Brazilian City, *Hum. Organ.* 79 (2020) 323–332, <https://doi.org/10.17730/1938-3525-79.4.323>.
- [30] F. Galli, S. Grandó, A. Adamsone-Fiskovica, H. Bjørkhaug, M. Czekaj, D.G. Duckett, H. Almaas, P. Karanikolas, O.M. Moreno-Pérez, D. Ortiz-Miranda, T. Pinto-Correia, P. Prospero, M. Redman, M. Rivera, I. Toma, P. Sánchez-Zamora, S. Šumane, K. Žmija, D. Žmija, G. Brunori, How do small farms contribute to food and nutrition security? Linking European small farms, strategies and outcomes in territorial food systems, *Glob. Food Sec.* 26 (2020) 100427, <https://doi.org/10.1016/j.gfs.2020.100427>.
- [31] S.M. Hashemi, A. Bagheri, N. Marshall, Toward sustainable adaptation to future climate change: insights from vulnerability and resilience approaches analyzing agrarian system of Iran, *Environ. Dev. Sustain.* 19 (2017) 1–25, <https://doi.org/10.1007/s10668-015-9721-3>.
- [32] B. Bajželj, T.E. Quedest, E. Rööös, R.P.J. Swannell, The role of reducing food waste for resilient food systems, *Ecosyst. Serv.* 45 (2020) 101140, <https://doi.org/10.1016/j.ecoser.2020.101140>.
- [33] V.B.B. Jernigan, T.L. Maudrie, C.J. Nikolaus, T. Benally, S. Johnson, T. Teague, M. Mayes, T. Jacob, T. Taniguchi, Food sovereignty indicators for indigenous community capacity building and health, *Front. Sustain. Food Syst.* 5 (2021) 1–9, <https://doi.org/10.3389/fsufs.2021.704750>.
- [34] G.M. Alam, M.N. Khatun, M.N.I. Sarker, N.P. Joshi, H. Bhandari, Promoting agri-food systems resilience through ICT in developing countries amid COVID-19, *Front. Sustain. Food Syst.* 6 (2023) 972667, <https://doi.org/10.3389/fsufs.2022.972667>.
- [35] Z. Chen, Q. Meng, K. Yan, R. Xu, The analysis of family farm efficiency and its influencing factors: evidence from rural China, *Land* 11 (2022) 1–19, <https://doi.org/10.3390/land11040487>.
- [36] E. Baker, R. Bezner Kerr, D. Deryng, A. Farrell, H. Gurney-Smith, P. Thornton, Mixed farming systems: potentials and barriers for climate change adaptation in food systems, *Curr. Opin. Environ. Sustain.* 62 (2023) 101270, <https://doi.org/10.1016/j.cosust.2023.101270>.
- [37] F. Sgroi, The circular economy for resilience of the agricultural landscape and promotion of the sustainable agriculture and food systems, *J. Agric. Food Res.* 8 (2022) 100307, <https://doi.org/10.1016/j.jafr.2022.100307>.
- [38] E. Barrios, B. Gemmill-Herren, A. Bicksler, E. Siliprandi, R. Brathwaite, S. Moller, C. Batello, P. Tiftonell, The 10 Elements of Agroecology: enabling transitions towards sustainable agriculture and food systems through visual narratives, *Ecosyst. People* 16 (2020) 230–247, <https://doi.org/10.1080/26395916.2020.1808705>.

- [39] K.N. Duc, T. Ancev, A. Randall, Farmers' choices of climate-resilient strategies: evidence from Vietnam, *J. Clean. Prod.* 317 (2021) 128399, <https://doi.org/10.1016/j.jclepro.2021.128399>.
- [40] G. Issahaku, A. Abdul-Rahaman, Sustainable land management practices, off-farm work participation and vulnerability among farmers in Ghana: is there a nexus? *Int. Soil Water Conserv. Res.* 7 (2019) 18–26, <https://doi.org/10.1016/j.iswcr.2018.10.002>.
- [41] B.B. Lin, Resilience in agriculture through crop diversification: adaptive management for environmental change, *Bioscience* 61 (2011) 183–193, <https://doi.org/10.1525/bio.2011.61.3.4>.
- [42] K. Mulungu, D. Kangogo, Striving to be resilient: the role of crop-poultry integrated system as a climate change adaptation strategy in semiarid eastern Kenya, *Heliyon* 8 (2022) e11579, <https://doi.org/10.1016/j.heliyon.2022.e11579>.
- [43] I.K. Mpanga, U.K. Schuch, J. Schalaus, Adaptation of resilient regenerative agricultural practices by small-scale growers towards sustainable food production in north-central Arizona, *Curr. Res. Environ. Sustain.* 3 (2021) 100067, <https://doi.org/10.1016/j.crsust.2021.100067>.
- [44] G. Craparo, E.I. Cano Montero, J.F. Santos Peñalver, Trends in the circular economy applied to the agricultural sector in the framework of the SDGs, *Environ. Dev. Sustain.* (2023) 1–11, <https://doi.org/10.1007/s10668-023-03750-8>.
- [45] A. Parveen, I. Pal, A. Witayangkurn, M. Pramanik, M. Nagai, H. Miyazaki, C. Wuthisakkaroon, Impacts of disaster and land-use change on food security and adaptation: evidence from the delta community in Bangladesh, *Int. J. Disaster Risk Reduc.* 78 (2022) 103119, <https://doi.org/10.1016/j.ijdrr.2022.103119>.
- [46] A.P. Barnes, S.G. Thomson, J. Ferreira, Disadvantage and economic viability: characterising vulnerabilities and resilience in upland farming systems, *Land Use Pol.* 96 (2020) 104698, <https://doi.org/10.1016/j.landusepol.2020.104698>.
- [47] M.N.I. Sarker, B. Hossain, G. Shi, R.B.R. Firdaus, Promoting net-zero economy through climate-smart agriculture: transition towards sustainability, *Sustain. Sci.* (2023), <https://doi.org/10.1007/s11625-023-01379-0>.
- [48] C. Lamine, Sustainability and resilience in agrifood systems: reconnecting agriculture, food and the environment, *Sociol. Rural.* 55 (2015) 41–61, <https://doi.org/10.1111/soru.12061>.
- [49] D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, Preferred reporting Items for systematic reviews and meta-analyses: the PRISMA statement, *PLoS Med.* 6 (2009) e1000097, <https://doi.org/10.1371/journal.pmed.1000097>.
- [50] A. Errington, R. Gasson, Labour use in the farm family business, *Sociol. Rural.* 34 (1994) 293–307, <https://doi.org/10.1111/j.1467-9523.1994.tb00814.x>.
- [51] M.A. Altieri, F.R. Funes-Monzote, P. Petersen, Agroecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty, *Agron. Sustain. Dev.* 32 (2012) 1–13, <https://doi.org/10.1007/s13593-011-0065-6>.
- [52] P.M. Rosset, M.E. Martínez-Torres, Rural social movements and agroecology: context, theory, and process, *Ecol. Soc.* 17 (2012), <https://doi.org/10.5751/ES-05000-170317>.
- [53] E. Holt-Giménez, M.A. Altieri, Agroecology, food sovereignty, and the new green revolution, *Agroecol. Sustain. Food Syst.* 37 (2013) 90–102, <https://doi.org/10.1080/10440046.2012.716388>.
- [54] S. Gliessman, Transforming food systems with agroecology, *Agroecol. Sustain. Food Syst.* 40 (2016) 187–189, <https://doi.org/10.1080/21683565.2015.1130765>.
- [55] S.K. Lowder, J. Skoet, T. Raney, The number, size, and distribution of farms, smallholder farms, and family farms worldwide, *World Dev.* 87 (2016) 16–29, <https://doi.org/10.1016/j.worlddev.2015.10.041>.
- [56] S. Contzen, J. Forney, Family farming and gendered division of labour on the move: a typology of farming-family configurations, *Agric. Hum. Val.* 34 (2017) 27–40, <https://doi.org/10.1007/s10460-016-9687-2>.
- [57] FAO, Putting family farmers at the centre to achieve the SDGs. <https://www.fao.org/3/ca4532en/ca4532en.pdf>, 2019.
- [58] P. Bonnal, P. Gasselin, Diversity of Family Farming Around the World, Springer Netherlands, Dordrecht, 2018, <https://doi.org/10.1007/978-94-024-1617-6>.
- [59] V. Alary, S. Messad, A. Aboul-Naga, M.A. Osman, T.H. Abdelsabour, A.-A.E. Salah, X. Juanes, Multi-criteria assessment of the sustainability of farming systems in the reclaimed desert lands of Egypt, *Agric. Syst.* 183 (2020) 102863, <https://doi.org/10.1016/j.agsy.2020.102863>.
- [60] N. Andrieu, F. Howland, I. Acosta-Alba, J.F. Le Coq, A.M. Osorio-García, D. Martínez-Baron, C. Gamba-Trimmiño, A.M. Loboguerrero, E. Chia, Co-Designing climate-smart farming systems with local stakeholders: a methodological framework for achieving large-scale change, *Front. Sustain. Food Syst.* 3 (2019) 2013–2017, <https://doi.org/10.3389/fsufs.2019.00037>.
- [61] S. Šūmane, I. Kunda, K. Knickel, A. Strauss, T. Tisenkopfs, I. des I. Rios, M. Rivera, T. Chebach, A. Ashkenazy, Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture, *J. Rural Stud.* 59 (2018) 232–241, <https://doi.org/10.1016/j.jrurstud.2017.01.020>.
- [62] E. Yeleliere, T. Yeboah, P. Antwi-Agyei, P. Pehrah, Traditional agroecological knowledge and practices: the drivers and opportunities for adaptation actions in the northern region of Ghana, *Reg. Sustain.* 3 (2022) 294–308, <https://doi.org/10.1016/j.regus.2022.11.002>.
- [63] Z. Wang, J. Li, P. Chen, Factors influencing Chinese flower and seedling family farms' intention to use live streaming as a sustainable marketing method: an application of extended theory of planned behavior, *Environ. Dev. Sustain.* 24 (2022) 4299–4322, <https://doi.org/10.1007/s10668-021-01616-5>.
- [64] Y. Gao, X. Zhang, J. Lu, L. Wu, S. Yin, Adoption behavior of green control techniques by family farms in China: evidence from 676 family farms in Huang-huaihai Plain, *Crop Protect.* 99 (2017) 76–84, <https://doi.org/10.1016/j.cropro.2017.05.012>.
- [65] J. Suess-Reyes, E. Fuetsch, The future of family farming: a literature review on innovative, sustainable and succession-oriented strategies, *J. Rural Stud.* 47 (2016) 117–140, <https://doi.org/10.1016/j.jrurstud.2016.07.008>.
- [66] J. Dreby, G. Jung, R. Sullivan, At the nexus of work and family: family farms in upstate New York, *J. Rural Stud.* 49 (2017) 151–161, <https://doi.org/10.1016/j.jrurstud.2016.12.001>.
- [67] J. Ketterman, B. Braun, M. Pippidis, Extension programming resource for building farm and farm family resilience, *J. Ext.* 58 (2020) 1–7.
- [68] Y. Gao, B. Liu, L. Yu, H. Yang, S. Yin, Social capital, land tenure and the adoption of green control techniques by family farms: evidence from Shandong and Henan Provinces of China, *Land Use Pol.* 89 (2019), <https://doi.org/10.1016/j.landusepol.2019.104250>.
- [69] S. de Bruin, J. Dengerink, J. van Vliet, Urbanisation as driver of food system transformation and opportunities for rural livelihoods, *Food Secur.* 13 (2021) 781–798, <https://doi.org/10.1007/s12571-021-01182-8>.
- [70] H. Hansson, R. Ferguson, C. Olofsson, L. Rantamäki-Lahtinen, Farmers' motives for diversifying their farm business - the influence of family, *J. Rural Stud.* 32 (2013) 240–250, <https://doi.org/10.1016/j.jrurstud.2013.07.002>.
- [71] K. Knickel, M. Redman, I. Darnhofer, A. Ashkenazy, T. Calvão Chebach, S. Šūmane, T. Tisenkopfs, R. Zemeckis, V. Atkociuniene, M. Rivera, A. Strauss, L. S. Kristensen, S. Schiller, M.E. Koopmans, E. Rogge, Between aspirations and reality: making farming, food systems and rural areas more resilient, sustainable and equitable, *J. Rural Stud.* 59 (2018) 197–210, <https://doi.org/10.1016/j.jrurstud.2017.04.012>.
- [72] I. Darnhofer, Strategies of family farms to strengthen their resilience, *Environ. Policy Gov.* 20 (2010) 212–222, <https://doi.org/10.1002/et.547>.
- [73] C. Guirkingner, J. Platteau, Transformation of the family farm under rising land pressure : a theoretical essay, *J. Comp. Econ.* 43 (2015) 112–137, <https://doi.org/10.1016/j.jce.2014.06.002>.
- [74] D. Wuepper, S. Wimmer, J. Sauer, Is small family farming more environmentally sustainable? Evidence from a spatial regression discontinuity design in Germany, *Land Use Pol.* 90 (2020) 104360, <https://doi.org/10.1016/j.landusepol.2019.104360>.
- [75] M.A. Altieri, V.M. Toledo, The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants, *J. Peasant Stud.* 38 (2011) 587–612, <https://doi.org/10.1080/03066150.2011.582947>.
- [76] S. Fan, P. Teng, P. Chew, G. Smith, L. Copeland, Food system resilience and COVID-19 – lessons from the Asian experience, *Glob. Food Sec.* 28 (2021) 100501, <https://doi.org/10.1016/j.gfs.2021.100501>.
- [77] L. Price, N. Evans, From stress to distress: conceptualizing the British family farming patriarchal way of life, *J. Rural Stud.* 25 (2009) 1–11, <https://doi.org/10.1016/j.jrurstud.2008.03.008>.
- [78] I. Unay-Gailhard, S. Bojnec, Gender and the environmental concerns of young farmers: do young women farmers make a difference on family farms? *J. Rural Stud.* 88 (2021) 71–82, <https://doi.org/10.1016/j.jrurstud.2021.09.027>.

- [79] F.I. Bánkuti, R.C. Prizon, J.C. Damasceno, M.M. De Brito, M.S.S. Pozza, P.G.L. Lima, Farmers' actions toward sustainability: a typology of dairy farms according to sustainability indicators, *Animal* 14 (2020) s417–s423, <https://doi.org/10.1017/S1751731120000750>.
- [80] D. Bertolozzi-Caredio, I. Bardaji, I. Coopmans, B. Soriano, A. Garrido, Key steps and dynamics of family farm succession in marginal extensive livestock farming, *J. Rural Stud.* 76 (2020) 131–141, <https://doi.org/10.1016/j.jrurstud.2020.04.030>.
- [81] E. Rösös, B. Bajzelj, C. Weil, E. Andersson, D. Bossio, L.J. Gordon, Moving beyond organic – a food system approach to assessing sustainable and resilient farming, *Glob. Food Sec.* 28 (2021), <https://doi.org/10.1016/j.gfs.2020.100487>.
- [82] E. Arabska, From farm to fork: human health and well-being through sustainable agri-food systems, *J. Life Econ.* 8 (2021) 11–27, <https://doi.org/10.15637/jlecon.8.1.02>.
- [83] M. Czekaj, A. Adamsone-Fiskovica, E. Tyran, E. Kilis, Small farms' resilience strategies to face economic, social, and environmental disturbances in selected regions in Poland and Latvia, *Glob. Food Sec.* 26 (2020) 100416, <https://doi.org/10.1016/j.gfs.2020.100416>.
- [84] J. Janker, S. Mann, Understanding the social dimension of sustainability in agriculture: a critical review of sustainability assessment tools, *Environ. Dev. Sustain.* 22 (2020) 1671–1691, <https://doi.org/10.1007/s10668-018-0282-0>.
- [85] P. Tittone, M. Fernandez, V.E. El Mujtar, P.V. Preiss, S. Sarapura, L. Labora, M.A. Mendonça, V.E. Alvarez, G.B. Fernandes, P. Petersen, I.M. Cardoso, Emerging responses to the COVID-19 crisis from family farming and the agroecology movement in Latin America – a rediscovery of food, farmers and collective action, *Agric. Syst.* 190 (2021), <https://doi.org/10.1016/j.agsy.2021.103098>.
- [86] V. Valencia, H. Wittman, J. Blesh, Structuring markets for resilient farming systems, *Agron. Sustain. Dev.* 39 (2019) 1–14, <https://doi.org/10.1007/s13593-019-0572-4>.
- [87] D.N. Mubiru, M. Radeny, F.B. Kyazze, A. Zziwa, J. Lwasa, J. Kinyangi, C. Mungai, Climate trends, risks and coping strategies in smallholder farming systems in Uganda, *Clim. Risk Manag.* 22 (2018) 4–21, <https://doi.org/10.1016/j.crm.2018.08.004>.
- [88] H. Gosnell, N. Gill, M. Voyer, Transformational adaptation on the farm: processes of change and persistence in transitions to 'climate-smart' regenerative agriculture, *Global Environ. Change* 59 (2019), <https://doi.org/10.1016/j.gloenvcha.2019.101965>.
- [89] H. Azadi, S. Movahhed Moghaddam, S. Burkart, H. Mahmoudi, S. Van Passel, A. Kurban, D. Lopez-Carr, Rethinking resilient agriculture: from climate-smart agriculture to vulnerable-smart agriculture, *J. Clean. Prod.* 319 (2021) 128602, <https://doi.org/10.1016/j.jclepro.2021.128602>.
- [90] Z. Assarkhaniki, A. Rajabifard, S. Sabri, The conceptualisation of resilience dimensions and comprehensive quantification of the associated indicators: a systematic approach, *Int. J. Disaster Risk Reduc.* 51 (2020) 1–18, <https://doi.org/10.1016/j.ijdrr.2020.101840>.
- [91] R. Goswami, K. Roy, S. Dutta, K. Ray, S. Sarkar, K. Brahmachari, M.K. Nanda, M. Mainuddin, H. Banerjee, J. Timsina, K. Majumdar, Multi-faceted impact and outcome of COVID-19 on smallholder agricultural systems: integrating qualitative research and fuzzy cognitive mapping to explore resilient strategies, *Agric. Syst.* 189 (2021) 103051, <https://doi.org/10.1016/j.agsy.2021.103051>.
- [92] Y. Gao, Z. Niu, H. Yang, L. Yu, Impact of green control techniques on family farms' welfare, *Ecol. Econ.* 161 (2019) 91–99, <https://doi.org/10.1016/j.ecolecon.2019.03.015>.
- [93] A. Bernard de Raymond, Detaching from agriculture? Field-crop specialization as a challenge to family farming in northern Côte d'Or, France, *J. Rural Stud.* 32 (2013) 283–294, <https://doi.org/10.1016/j.jrurstud.2013.07.007>.
- [94] S. Dogliotti, M.C. García, S. Peluffo, J.P. Dieste, A.J. Pedemonte, G.F. Bacigalupe, M. Scarlato, F. Alliaume, J. Alvarez, M. Chiappe, W.A.H. Rossing, Co-innovation of family farm systems: a systems approach to sustainable agriculture, *Agric. Syst.* 126 (2014) 76–86, <https://doi.org/10.1016/j.agsy.2013.02.009>.
- [95] M. Borychowski, S. Stepień, J. Polcyn, A. Tošović-Stevanović, D. Calović, G. Lalić, M. Žuža, Socio-economic determinants of small family farms' resilience in selected central and eastern European countries, *Sustainability* 12 (2020) 10362, <https://doi.org/10.3390/su122410362>.
- [96] D. Lucantoni, Transition to agroecology for improved food security and better living conditions: case study from a family farm in Pinar del Río, Cuba, *Agroecol. Sustain. Food Syst.* 44 (2020) 1124–1161, <https://doi.org/10.1080/21683565.2020.1766635>.
- [97] H. Kendall, B. Clark, W. Li, S. Jin, G.D. Jones, J. Chen, J. Taylor, Z. Li, L.J. Frewer, Precision Agriculture Technology Adoption: a Qualitative Study of Small-Scale Commercial "Family Farms" Located in the North China Plain, Springer US, 2022, <https://doi.org/10.1007/s11119-021-09839-2>.
- [98] A. Ashkenazy, T. Calvão Chebach, K. Knickel, S. Peter, B. Horowitz, R. Offenbach, Operationalising resilience in farms and rural regions – findings from fourteen case studies, *J. Rural Stud.* 59 (2018) 211–221, <https://doi.org/10.1016/j.jrurstud.2017.07.008>.
- [99] M. Mascarenhas, Farming systems research: flexible diversification of a small family farm in southeast Michigan, *Agric. Hum. Val.* 18 (2001) 391–401, <https://doi.org/10.1023/A:1015233512117>.
- [100] L. Marchetti, V. Cattivelli, C. Cocozza, F. Salbitano, M. Marchetti, Beyond sustainability in food systems: perspectives from agroecology and social innovation, *Sustainability* 12 (2020) 7524, <https://doi.org/10.3390/su12187524>.
- [101] Y. Lu, Y. Zhang, Y. Hong, L. He, Y. Chen, Experiences and lessons from agri-food system transformation for sustainable food security: a review of China's practices, *Foods* 11 (2022), <https://doi.org/10.3390/foods11020137>.
- [102] B. Agarwal, Can group farms outperform individual family farms? Empirical insights from India, *World Dev.* 108 (2018) 57–73, <https://doi.org/10.1016/j.worlddev.2018.03.010>.
- [103] J.L. Durant, L. Asprooth, R.E. Galt, S.P. Schmulevich, G.M. Manser, N. Pinzón, Farm resilience during the COVID-19 pandemic: the case of California direct market farmers, *Agric. Syst.* 204 (2023), <https://doi.org/10.1016/j.agsy.2022.103532>.
- [104] G. Arcese, F. Fortuna, M.G. Pasca, The sustainability assessments of the supply chain of agri-food products: the integration of socio-economic metrics, *Curr. Opin. Green Sustainable Chem.* 40 (2023) 100782, <https://doi.org/10.1016/j.cogsc.2023.100782>.
- [105] Z. xiong Du, X. dong Lai, W. jin Long, L. liang Gao, The short- and long-term impacts of the COVID-19 pandemic on family farms in China – evidence from a survey of 2 324 farms, *J. Integr. Agric.* 19 (2020) 2877–2890, [https://doi.org/10.1016/S2095-3119\(20\)63390-1](https://doi.org/10.1016/S2095-3119(20)63390-1).
- [106] F.F. Fagioli, L. Rocchi, L. Paolotti, R. Słowiński, A. Boggia, From the farm to the agri-food system: a multiple criteria framework to evaluate extended multi-functional value, *Ecol. Indic.* 79 (2017) 91–102, <https://doi.org/10.1016/j.ecolind.2017.04.009>.
- [107] F.X. Aguilar, D. Hendrawan, Z. Cai, J.M. Roshetko, J. Stallmann, Smallholder Farmer Resilience to Water Scarcity, Springer Netherlands, 2022, <https://doi.org/10.1007/s10668-021-01545-3>.
- [108] B.A. Baker, B.H. Alexander, J.S. Mandel, J.F. Acquavella, R. Honeycutt, P. Chapman, Farm Family Exposure Study: methods and recruitment practices for a biomonitoring study of pesticide exposure, *J. Expo. Anal. Environ. Epidemiol.* 15 (2005) 491–499, <https://doi.org/10.1038/sj.jea.7500427>.
- [109] S. Zollet, L. Colombo, P. De Meo, D. Marino, S.R. McGreevy, N. McKeon, S. Tarra, Towards territorially embedded, equitable and resilient food systems? Insights from grassroots responses to COVID-19 in Italy and the city region of Rome, *Sustainability* 13 (2021) 2425, <https://doi.org/10.3390/su13052425>.
- [110] A. Wijerathna-Yapa, R. Pathirana, Sustainable agro-food systems for addressing climate change and food security, *Agriculture* 12 (2022) 1554, <https://doi.org/10.3390/agriculture12101554>.
- [111] N. Paganini, K. Adinata, N. Buthelezi, D. Harris, S. Lemke, A. Luis, J. Koppelin, A. Karriem, F. Ncube, E. Nervi Aguirre, T. Ramba, I. Raimundo, N. Sulejmanović, H. Swanby, D. Tevera, S. Stöber, E.N. Aguirre, T. Ramba, I. Raimundo, N. Sulejmanović, H. Swanby, D. Tevera, S. Stöber, Growing and eating food during the COVID-19 pandemic: farmers' perspectives on local food system resilience to shocks in Southern Africa and Indonesia, *Sustainability* 12 (2020) 1–26, <https://doi.org/10.3390/su12208556>.
- [112] R.W. Corbett, M.L. Pories, R.T. Marcom, M.A. Rose, When your patient is a farm family: challenges farm wives perceive in promoting farm family health, *J. Nurse Pract.* 16 (2020) 457–460, <https://doi.org/10.1016/j.nurpra.2020.03.010>.
- [113] M.D.C. Anderson, The role of knowledge in building food security resilience across food system domains, *J. Environ. Stud. Sci.* 5 (2015) 543–559, <https://doi.org/10.1007/s13412-015-0311-3>.
- [114] K. Bronson, I. Knezevic, C. Clement, The Canadian family farm, in literature and in practice, *J. Rural Stud.* 66 (2019) 104–111, <https://doi.org/10.1016/j.jrurstud.2019.01.003>.

- [115] P. Ballamingie, A. Blay-Palmer, I. Knezevic, A. Lacerda, E. Nimmo, L. Stahlbrand, R. Ayalon, Integrating a food systems lens into discussions of urban resilience: a policy analysis, *J. Agric. Food Syst. Community Dev.* 9 (2020) 1–17, <https://doi.org/10.5304/jafscd.2020.093.021>.
- [116] M.N.I. Sarker, Livelihood resilience of climate-induced displaced people in South Asia: implications for Bangladesh, in: *Disaster, Displac. Resilient Livelihoods Perspect. From South Asia*, Emerald Publishing Limited, 2023, pp. 81–98, <https://doi.org/10.1108/978-1-80455-448-720231005>.
- [117] Y. Lv, M.N.I. Sarker, R.B.R. Firdaus, Disaster resilience in climate-vulnerable community context: conceptual analysis, *Ecol. Indic.* 158 (2024) 111527, <https://doi.org/10.1016/j.ecolind.2023.111527>.