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ARTICLE

Formulating Strategies for Improving Food Security among Smallholder Farmers in The Middle Jordan Valley (Ghawr)

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ABSTRACT

The challenges faced by smallholder farmers are a critical issue for sustainable development, particularly in food security. Smallholder farmers in the Middle Jordan Valley face multiple constraints such as land degradation, climate change, limited market access, and inadequate resources. These pressures have led to migration out of agriculture, exacerbated by weak policies and regional conflicts. This study aims to analyse the factors affecting smallholder farmers' food security, including key challenges, agricultural practices, and drivers of migration, and to explore strategies to strengthen food security in the region. This study used a qualitative approach with a survey method among smallholder farmers in the Middle Jordan Valley. The results showed that key challenges include high input costs, crop diseases, mounting debt, complex export policies, and water constraints due to extreme climates. The analysis identified two quadrants of push factors: Quadrant 1 covers short-term impacts such as financial, nutritional, and health pressures, while Quadrant 2 contains long-term impacts such as youth dissatisfaction with the agricultural sector due to unsupportive policies. This study provides policy recommendations to maintain the sustainability of agriculture in the Middle Jordan Valley. The proposed measures include the development of water-efficient irrigation strategies, implementing environmentally friendly agricultural practices, and reforming export policy, strengthening local market access, providing agricultural input subsidies, strengthening farmer coop-

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eratives, and income diversification programs and new skills education. These recommendations aim to improve the welfare of small farmers and attract the younger generation's interest in continuing to contribute to the agricultural sector.

Keywords: Food Security; Policy; Push Factors; Smallholder Farmers; Sustainability

1. Introduction

Understanding smallholder farmers' challenges has become an important focus in sustainable development studies, especially in food security [1,2]. From an epistemological perspective, this study is based on a multidisciplinary approach that links socio-economic dynamics, agricultural practices, and public policies. This approach allows for a holistic analysis to understand how the interaction between these factors affects smallholder farmers' productivity and food security, particularly in the Middle Valley region of Jordan [3,4]. This study also starts from the assumption that food security depends not only on food availability but also on accessibility, stability, and community preferences for food. The main problem faced is the low level of food security among smallholder farmers, exacerbated by various challenges such as land degradation, climate change, limited access to markets, and inadequate resources [5,6]. In addition, weak policies that support food security for small farmers further worsen the situation, so that many farmers are forced to seek livelihoods outside the agricultural sector [7,8]. As a result, local food production is reduced, which ultimately threatens regional food security.

While there has been extensive research on food security and the impacts of climate change on the agricultural sector, there is a research gap in understanding the linkages between key challenges such as migration, resource access, and agricultural practices with food security outcomes in a comprehensive manner. For example, a study by [9] highlights the importance of investing in agricultural technology to improve smallholder farmer productivity but places less emphasis on the socio-economic factors that drive out-migration from the agricultural sector. Another study by [10] shows that subsidy policies can support smallholder farmers, but do not address structural constraints such as unequal access to resources. To bridge this gap, a holistic framework is needed to assess how various livelihood factors interact to shape food security outcomes, particularly in vulnerable agricultural regions.

To clarify the scope of this research, food security is defined according to the Food and Agriculture Organization (FAO) as a condition in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences for an active and healthy life [9]. This definition underpins the multidimensional nature of food security, encompassing availability, access, utilization, and stability. While extensive studies have addressed the impact of climate change and policy on food security, a significant gap exists in understanding how these elements intersect with migration trends and livelihood assets among smallholder farmers in vulnerable regions like the Middle Jordan Valley [11,12]. Existing research has largely focused on technological or policy interventions in isolation, often neglecting the socio-economic dynamics that influence farmers' decisions to exit agriculture [2,9–38]. This study is motivated by the need to provide a holistic perspective that not only identifies the challenges but also proposes integrated strategies for enhancing food security, thereby contributing to both theoretical advancement and practical policymaking in the field.

The Sustainable Livelihood Framework (SLF) provides a structured approach to analysing how smallholder farmers navigate constraints and opportunities in maintaining their agricultural livelihoods. This framework emphasizes the interaction between five key livelihood assets, such as human, social, natural, physical, and financial and how these assets influence food security outcomes. Given the complexity of challenges in the Middle Jordan Valley, SLF helps capture the multidimensional aspects of food security, recognizing that access to resources, institutional support, and adaptive capac-

ity are essential for sustaining agricultural livelihoods. The SLF also highlights the role of vulnerability contexts, such as climate variability, market fluctuations, and policy limitations, in shaping the livelihood strategies of smallholder farmers. By employing SLF, this study examines the dynamic relationships between livelihood assets and food security, identifying both constraints and potential intervention points. The framework allows for a more nuanced understanding of how farmers cope with environmental and economic pressures, as well as how policy and governance influence their decision-making. Integrating SLF into this research ensures a comprehensive assessment of smallholder resilience and adaptation strategies, contributing valuable insights into how food security can be strengthened through targeted policy and resource allocation.

This study aims to analyse the factors that influence smallholder farmers' food security, including agricultural practices, the main challenges they face, and the drivers of migration from the agricultural sector. It also seeks to explore the relationship between these dominant challenges and to find relevant strategies to strengthen food security for smallholder farmers, particularly in the Middle Valley region of Jordan. Thus, this study provides not only theoretical contributions but also practical implications to support more inclusive development policies and programs.

2. Literature Review

Recent literature increasingly highlights the critical role of integrated resource management and community-based approaches in strengthening food security. For instance, the work of [11] emphasizes the value of localized water management practices in semi-arid regions, while [38] explores how cooperative-based marketing can enhance the resilience of Jordanian smallholders. However, these studies often overlook the complex drivers of migration and the interaction among different livelihood assets gaps that this paper aims to address [39,40]. Furthermore, food security continues to evolve in response to emerging global challenges, requiring continuous updates and context-specific interpretations, particularly in regions affected by environmental and socio-political stressors.

Comparative studies reveal that the food security challenges faced by Jordan are echoed across neighboring countries such as Egypt, Morocco, and Tunisia [2,32–36]. For example, in Egypt's Nile Delta, water mismanagement and climate change have led to a marked decline in agricultural productivity, spurring rural-to-urban migration. Similarly, Morocco's drylands are grappling with erratic rainfall and desertification, mirroring Jordan's climatic pressures [39,41]. These comparisons highlight shared vulnerabilities and support the potential for applying regionally adapted strategies.

Despite extensive research on agricultural productivity, gaps remain in understanding the socio-economic and migration-related dynamics that underpin food insecurity. Few studies examine how social networks, remittances, and labor migration influence the resilience of farming households [40,41]. Addressing these aspects is essential to achieving a more holistic understanding of food security across the MENA region.

In addition to Jordan, many countries in the MENA region, such as Egypt, Tunisia, and Lebanon, face parallel challenges, including water scarcity, land degradation, and socio-political instability [36,41]. Research from these contexts emphasizes the compounded effects of environmental stress and economic constraints on food systems [9,12,31]. There is also a growing body of literature highlighting the role of both internal and international migration as responses to food insecurity. However, limited attention has been given to how livelihood transformations, cultural norms, and migration decisions intersect. This study contributes to filling that gap by examining how socio-economic pressures and migration patterns in the Middle Jordan Valley influence smallholder farmers' resilience and food security.

3. Materials and Methods

3.1. Research Design

This study employed a mixed-method approach, integrating qualitative interviews with field-level experimental data to explore the complex relationship between livelihood assets and food security among smallholder households in the Middle Jordan Valley. A qualitative case study design was adopted due to its flexibility in

facilitating in-depth and comprehensive investigations of multifaceted issues [13]. Semi-structured interviews with open-ended questions were conducted to capture nuanced insights into how different livelihood assets influence household food security. The study was able to explore smallholder farmers' lived experiences in great detail by concentrating on the Middle Jordan Valley, revealing field-level patterns that could otherwise go unnoticed.

3.2. Participants and Procedures

The study involved participants consisting of smallholder farmers in the Middle Jordan Valley who manage agricultural land of less than three hectares and focus on vegetable cultivation. The number of participants was determined to be 15 households, selected purposively based on predetermined inclusion criteria, such as a minimum of two years of farming experience and willingness to participate in interviews. Participant data were obtained from official records of relevant authorities, such as the Jordan Valley Authority (JVA), as well as input from public and private sector experts. The data collection procedure was carried out in two stages: a preparation stage involving participant selection and providing information related to the study, and an interview stage as the main data collection method.

The sample size of 15 households, though limited, was selected purposively to ensure depth of insight over breadth, which is aligned with qualitative case study methodology, where the focus is on rich, contextualized understanding rather than statistical generalization [13]. Each participant was chosen to represent key characteristics of the farming community, ensuring diversity in terms of age, farm size, and market participation. While the small sample size limits the generalizability of findings, it enhances the validity of the in-depth qualitative analysis [6]. The randomness of selection within the purposive criteria, combined with cross-verification using official records and sector experts, helps reinforce the scientific rigor and representativeness of the study sample within the targeted region [12,21].

The study employed a purposive sampling approach to select smallholder farmers in the Middle Jordan Valley who are actively engaged in agricultural production and are directly impacted by food security challenges. 45 farmers from 15 households were interviewed, selected based on their geographic distribution, farm size, and willingness to participate. This approach ensured diversity in farm practices and socio-economic backgrounds. Although qualitative insights were the primary focus, quantitative data such as average input costs, annual crop yields, and household migration rates were also collected where available to support the analysis and provide more grounded conclusions.

3.3. Instruments and Measured Variables

The main instrument in this study was a semi-structured interview guide with open-ended questions designed to explore livelihood assets, such as social, human, natural, financial, and physical, and their relationship to household food security. The study also used secondary data from literature studies, government reports, and official statistical data to strengthen the analysis. Interview data were recorded in Arabic, transcribed, and translated into English. The validity of the data was ensured through a member-checking process, where interview transcripts were given back to participants for verification (**Table 1**). In addition, the study adhered to ethical guidelines, ensuring voluntary participation and confidentiality. Triangulation with secondary data (such as government statistics and reports) further strengthened the credibility of the findings.

Table 1. Instrument and Measured Variable.

Variables	Instruments	Respondents (Households)
Social Asset	A semi-structured interview guide with open-ended questions and a literature study	15
Human Asset	A semi-structured interview guide with open-ended questions	15
Natural Asset	A semi-structured interview guide with open-ended questions and government reports	15
Financial Asset	A semi-structured interview guide with open-ended questions and statistical report	15
Physical Asset	A semi-structured interview guide with open-ended questions	15

3.4. Supplementary Experimental Observations

In addition to the 15 in-depth interviews conducted with stakeholders, the study incorporated complementary experimental data collected through a field-based observation approach. This involved monitoring three selected community farming areas over four months (June 2024–October 2024) to assess crop growth performance, land productivity, and food availability under different local farming strategies. Key indicators included land area under cultivation, yield per hectare for staple crops, frequency of crop failure due to environmental factors, and access to food supply during peak and lean seasons. These observations were triangulated with interview findings to strengthen data validity and highlight patterns not always captured through verbal responses. By blending interview narratives with direct measurement and monitoring, the research delivers a more comprehensive view of local food security dynamics.

3.5. Data Analysis

The data analysis process in this study was carried out in stages and systematically. The first stage was transcription, where interview recordings were converted into structured text documents. Next, the data were categorized based on the DFID (Sustainable Livelihood Framework) framework, where key categories and themes were identified. The data filtering process was carried out to eliminate less relevant information. The data were then coded, which helped organize and tag the data according to emerging themes or patterns. The results of the data analysis were then presented in the form of key themes, focusing on the relationship between livelihood assets and smallholder food security strategies. The data were also compared with findings from previous literature to ensure the consistency and relevance of the research results. This analysis process involved validation by participants to ensure data reliability, as well as in-depth analysis to explain how smallholder farmers use livelihood assets to achieve desired livelihood outcomes amidst limited resource challenges.

4. Results

The study's findings underscore the primary obstacles encountered by smallholder farmers in the Middle Jordan Valley, stressing how interrelated these limitations are. This research highlights important elements like resource constraints, disruptions to the environment, and policy flaws that influence farmers' resilience and adaptive strategies by examining how agricultural difficulties affect smallholders' livelihoods and food security via the Sustainable Livelihood Framework (SLF).

4.1. Analysing Demographic Data of Respondents

Table 2 describes the profile of respondents involved in the study on the relationship between livelihood assets and household food security. The majority of respondents are male heads of household with an average age of 46.8 years, indicating that they are in their productive age with long experience in managing agriculture. As many as 80% of respondents are married, reflecting strong family responsibilities, especially since all respondents are heads of households who are responsible for their family's needs. On average, respondents have six dependents, meaning they must ensure that agricultural income is sufficient for the needs of family members. The level of education in agriculture is quite high, with 67% of respondents having a diploma related to agriculture. This supports their ability to apply modern farming techniques, but challenges remain as the average monthly income from farming is only 633.33 JOD. Meanwhile, the average work experience in the agricultural sector is 21.6 years, indicating that these farmers have in-depth expertise and a good understanding of agricultural practices in their area. All respondents owned private land, with an average land area of 28.31 dunams (or about 2.83 hectares). However, this limited land size can be one of the reasons for limited income, especially when combined with limited resources such as water or access to modern agricultural technology. Complete dependence on agriculture as the main source of income represents a high risk to household food security, especially in the event of crop failure or market price

fluctuations. This research supports the research of[14] The relationship between these livelihood assets shows that education level, experience, and good land ownership are supporting factors in agricultural management. However, low income indicates the need for income diversification or increased efficiency in land management to improve household food security. This result is in line with the research of[15,16].

Table 2. Informant Information.

Variable	Description	Average
Age, year	Age of the respondents in years	46.8
Gender, %	The gender of the respondents, Male	80
Marital Status, %	Marital status of the respondents, Married	80
Family Responsibility, %	Role in family, Head of household	100
Number of Dependents, member	Number of family members depending on the respondent	6
Education in Agriculture, %	Education level related to agriculture, Diploma	67
Agriculture Experience, year	Years of experience in agriculture	21.6
Land Ownership Type, %	Ownership type of agricultural land, Landowner	100
Land Size (Dunams[1])	Size of land owned by respondents in dunams	28.31
Income Sources, JOD[2]	Sources of monthly income, Farm (Land)	633.33

Note: [1/] 1 Dunam (0,1 ha); [2/] JOD (1,41 USD).

4.2. Exploring Agricultural Activities of Smallholder Farmers

An overview of the farming systems practiced by smallholder farmers in the Middle Jordan Valley is provided in **Table 3**. Common crops grown include a variety of vegetables, such as cucumbers, tomatoes, leafy vegetables, eggplants, peppers, beans, okra, and potatoes. These crop choices reflect the needs of local and international markets, where fresh vegetables are in high demand. However, these choices are also influenced by farmers' ability to adapt to environmental conditions and the availability of resources, such as irrigation water. The average cropping cycle is 2.2 times per year, with variations ranging from one to three cycles, depending on the type of crop, season, and irrigation system used. Fewer cycles are usually due to water constraints or soil recovery time, while more cycles indicate resource optimization through technologies such as greenhouses.

Table 3. Agriculture Activities of Smallholder Farmers.

Aspect	Summary/Average
Crop types, species	Common crops include cucumbers, tomatoes, leafy vegetables, eggplants, peppers, beans, okra, and potatoes.
Cycles, year	Average: 2.2 cycles/year (ranging from 1–3 cycles).
Farming system	Combination of greenhouses and open-field farming, with a significant portion adopting drip irrigation.
Farming style	Predominantly irrigated farming. A mix of modern and traditional practices based on market demands and financial constraints.
Cultivation practices	Modern using drip irrigation, and greenhouses for productivity. Traditional using simple drip irrigation, and local seeds to reduce costs.
Farm management	Typically managed by the owner, with assistance from family members and hired seasonal labor (Egyptian workers most common). Permanent workers range from 1–2 per farm. Seasonal workers are hired as needed during peaks.

The farming system used is a combination of greenhouses and open fields, with widespread adoption of drip irrigation technology. This system not only improves water efficiency but also maximizes crop yields, especially in areas facing limited water resources. However, not all farmers can fully convert to modern technology due to financial constraints or limited access to information and technology. As a result, traditional practices such as simple drip irrigation and the use of local seeds to reduce costs persist. Farm management is generally carried out directly by the landowner with the help of family members and seasonal workers. Permanent workers on each plot usually range from one to two people, while seasonal workers, mostly Egyptian,

are employed during peak activities such as planting and harvesting. This reliance on seasonal workers demonstrates the importance of labor flexibility in maintaining agricultural productivity. However, this factor can also be influenced by the availability of labor in the market and the level of wages that farmers must pay. This result also happened in the research [17].

The combination of modern and traditional practices reflects farmers' efforts to balance market demands with the constraints they face. Modernisations such as drip irrigation and greenhouses help increase productivity, but cost constraints and the risk of crop failure mean many farmers continue to use traditional methods as a strategy to reduce financial risk. These data underscore the importance of additional support, such as technology training, access to markets, and subsidies, to improve food security and the livelihoods of smallholder farmers in the region. A combination of traditional and modern methods is a common adaptive strategy to meet market demand while maintaining household food security. For example, Farmer 1 explained, "*I balance between traditional and modern farming practices based on market demand, available resources, and expertise,*" indicating that their decisions are heavily influenced by the availability of capital and resources. Financial capital allows for the adoption of modern methods such as drip irrigation or greenhouses, while limited funds force them to revert to traditional practices such as the use of local seeds or flood irrigation. However, Farmer 6 highlighted the challenges of climate change and water scarcity, "*Even these methods no longer yield results as they used to due to climate changes and water scarcity.*"

Cultivated crops include a variety of vegetables such as cucumbers, tomatoes, eggplants, peppers, and potatoes, reflecting local and international market needs. However, the choice of crops is also influenced by environmental conditions and the availability of resources, especially irrigation water. The average planting cycle is 2.2 times per year, with variations between one and three cycles depending on the type of crop, season, and irrigation system used. Technologies such as greenhouses and drip irrigation are often used to optimize yields, as Farmer 10 noted "*To meet market demand, for example, protected farming is more successful in the middle Jordan Valley. Currently, all areas of the Jordan Valley use drip irrigation.*" These technologies help improve water efficiency and productivity, although not all farmers can adopt them due to financial constraints.

To add more, labor management is also an important factor. Many farmers manage their land independently with the help of family members to save costs, as Farmer number 3 did "I *manage the farm myself with the help of three family members to save costs.*" However, when farming activity increases, such as during the harvest season, they often employ seasonal labor, as expressed by Farmer number 13, who uses Pakistani and Syrian labor. Despite modernisation efforts, some farmers still maintain traditional practices as a strategy to reduce the risk of crop failure. Farmer number 15 explained, "*My choice depends on available capital; for example, if I have money during a certain season, I might opt for protected agriculture,*" emphasizing the importance of capital availability in determining the choice of cultivation system. This condition shows that although modernisation such as drip irrigation and greenhouses increases efficiency, many farmers face barriers such as high costs and environmental risks [18,19].

4.3. Assessing Food Status Among Smallholder Farmers

Food security status among smallholder farmers shows a significant contribution of agricultural land to family food needs, reaching an average of 59.33% (**Table 4**). However, the challenges faced are very diverse, ranging from limited resources to climate change. Most farmers emphasized the importance of ensuring sustainable food availability for all family members without prioritizing based on age or certain groups. Farmer number 1 stated, "*We focus on growing essential crops such as seasonal vegetables that can meet family food needs and reduce dependence on the market.*" This statement describes their strategy for managing limited resources, including storing harvests for personal use.

Crop diversification was a top priority for most farmers as farmer number 5 expressed, "*We try to diversify our crops to avoid dependence on one crop and to store produce from different seasons for use in times of*

low production." However, economic conditions and limited resources often limit this flexibility. Farmer number 6 added, "*Weather fluctuations, high input costs, and resource constraints make it difficult for us to grow as many crops as we would like.*" This suggests that barriers such as water scarcity and expensive seeds or fertilizers affect farmers' ability to maintain food diversity. In addition, most families depend on agricultural products to meet their basic needs, with an average of 85.33% of respondents expressing concerns about running out of food. Farmer number 15 highlighted the importance of irrigation water by saying, "*The main priority for food security is to ensure sufficient irrigation water because agriculture is highly dependent on water availability.*" This confirms the relationship between limited natural resources and family food security. As a result of economic challenges, an average of 72.66% of families reduced their food consumption, often eating only one or two meals a day. Farmer number 7 said, "*My children only eat one meal a day, and I struggle to provide additional money so they can buy food at school*". This situation reflects the economic impact on family consumption patterns, where adults tend to prioritize children in food distribution. This research is in line with [20].

Table 4. Food Status Among Smallholder Farmers.

Category	Summary
Farm contribution to food needs	The farm is the primary source of food for most families, contributing an average of 59% to their food security.
Prioritized aspects of food security	The main priority is ensuring a continuous food supply for all family members, with an emphasis on growing essential crops, diversifying production, and minimizing market reliance.
Enough food and variety	Most families struggle with food variety due to economic conditions, with reliance on the crops they grow. Many families reported limited variety, particularly due to income and crop yield issues.
Concern over food running out	The majority of respondents 85% express concern about running out of food, often related to unpredictable crop yields, financial instability, or rising market prices.
Reduced food consumption	On average, families have had to reduce food consumption, often limiting meals to one or two per day, particularly when financial resources are low.
Adults skipping meals	A smaller portion of respondents that13% reported adults skipping meals. This occurred during financial hardship or when prioritizing children or medical emergencies.

5. Discussion

5.1. Empirical Validation through Field Observations

To enhance the depth and credibility of this study, the integration of qualitative insights from interviews with experimental field data provides a multidimensional understanding of smallholder agricultural dynamics and food security outcomes. The zones selected for experimental observation, conducted between June 2024–October 2024, revealed distinct differences in access to agricultural inputs, levels of institutional engagement, and food security. When compared with demographic and behavioral data (**Tables 2**–**4**), these findings offer a more holistic view of the realities faced by smallholder farmers, grounding statistical patterns in the lived experiences of the communities studied.

The experimental outcomes align closely with the demographic profile of the respondents (**Table 2**), where the average age was 46.8 years, and the farmers had an average of 21.6 years of experience. This long-standing engagement in agriculture reflects a deep-rooted knowledge of land use and cropping patterns. However, despite their experience, 85% of the farmers expressed anxiety over food insecurity, a concern that is echoed in the poor outcomes observed in Zone C. This zone, characterized by minimal institutional support and a continued reliance on traditional farming methods, reported the lowest yields at only 1.8 tons per hectare. Interestingly, all respondents owned their farmland, averaging 28.31 dunams each, suggesting that food insecurity is not a consequence of land access but rather of limited capacity to utilize the land efficiently. Zone A exemplified effective land use, achieving the highest yield

(3.5 tons/ha) through diverse cropping, greenhouse systems, and sustainable irrigation practices, which collectively contributed to stronger food security.

Crop management practices, as summarized in **Table 3**, further illuminate these differences. Across all zones, farmers averaged 2.2 cropping cycles per year, often combining greenhouse and open-field systems. This approach was most effective in Zone A, where a variety of short-cycle vegetables, including tomatoes, cucumbers, and leafy greens, ensured continuous food availability, even during seasonal changes. The integration of drip irrigation systems with low-cost traditional inputs enabled farmers to manage resources more efficiently and maintain higher productivity. In contrast, Zone B, despite enjoying moderate institutional support, failed to fully utilize innovative practices. Its reliance on less diverse cropping systems limited land-use efficiency and impacted soil health, revealing that access to modern tools alone does not guarantee improved outcomes unless paired with ecological responsiveness and strategic diversification.

The implications of these agricultural practices are directly reflected in the food security indicators presented in **Table 4**. Although farms contributed approximately 59% of household food needs, many families struggled with dietary variety and sufficiency. Experimental data confirmed that Zones A and B maintained more stable food supplies during periods of unseasonal rainfall, owing largely to their more adaptive cropping systems and better access to support services. Conversely, over 65% of households in Zone C faced food shortages, a finding that corresponds with survey responses in which 85% of participants expressed fears of food depletion, and 13% admitted to adults skipping meals due to financial stress. These insights highlight the importance of sustainable, multi-crop farming systems in buffering against climate and economic shocks while reducing reliance on market-purchased food.

Institutional support emerged as a critical factor in building agricultural resilience. With 67% of respondents holding diplomas in agriculture, the potential for adopting innovative practices is high when backed by institutional frameworks. Zones A and B benefitted from active support by agricultural extension officers, which enhanced their ability to respond to environmental challenges. This was evident in the fact that 80% of households in these zones were able to maintain adequate food stocks during lean periods. These findings underscore the pivotal role of timely information, guidance, and knowledge-sharing in stabilizing local food systems.

Finally, land-use efficiency, another crucial aspect, varied significantly across the zones. Zone A achieved an efficiency rate of 85%, supported by a strategic integration of greenhouse and open-field farming that allowed for up to three cropping cycles annually. This contrasts with the 50% efficiency rate in Zone C, where limited adoption of technology, lack of irrigation infrastructure, and inability to rotate crops severely hampered productivity. Nevertheless, across all zones, a hybrid approach combining modern tools, such as drip irrigation and greenhouses, with traditional methods like the use of local seeds and simpler irrigation systems was commonly observed. These blended practices not only reflect financial constraints and varying access to resources but also point to the enduring value of indigenous knowledge. Many older farmers emphasized that traditional methods play a key role in maintaining soil health and crop resilience, especially when integrated thoughtfully with modern innovations.

Recognizing and institutionalizing this synergy between traditional wisdom and contemporary techniques is essential for optimizing land use and ensuring long-term sustainability. As the study shows, such integrative farming systems, when supported by education, infrastructure, and responsive institutions, can substantially improve productivity, food security, and resilience for smallholder farmers.

Building upon this understanding, the integration of experimental findings into a summarized zonal comparison offers a concise yet insightful snapshot of how varying degrees of institutional support, land use practices, and cropping patterns directly impact agricultural performance and food security outcomes. **Table 5** below encapsulates these key differences across the three study zones. It highlights how Zone A, with its stronger institutional backing and adoption of diverse crops and modern techniques like drip irrigation and greenhouses, achieved the highest yield and land-

use efficiency alongside the lowest food shortage incidence. In contrast, Zone C, marked by weak institutional engagement and reliance on traditional, less intensive farming methods, experienced the lowest productivity and highest food insecurity. Zone B presents a middle ground, where moderate support and partially modernized practices lead to moderate outcomes. This comparative view reinforces the earlier conclusion that the synergy of traditional knowledge and modern innovation, underpinned by supportive institutions, is vital for enhancing the resilience and sustainability of smallholder farming systems.

Table 5. Challenges Impact on Food Security.

Zone	Average Yield (tons/ha)	Land Use Efficiency (%)	Institutional Support	Food Shortage Incidents	Cropping Pattern
A	3.5	85%	Strong	Low (20%)	Diverse crops (vegetables like cucumbers, tomatoes, eggplants, etc.), average 2–3 cycles/year, use of greenhouses and drip irrigation
B	2.7	65%	Moderate	Moderate (35%)	Mixed cropping with limited species, average 2 cycles/year, partial use of drip irrigation and open-field farming
C	1.8	50%	Weak	High (65%)	Traditional mixed cropping, average 1–2 cycles/year, minimal infrastructure, simple irrigation, use of local seeds

5.2. Identifying Key Challenges on Food Security

The challenges in the agricultural sector have a significant impact on food security, especially for small farmers and consumers (**Table 6**). High costs of agricultural inputs, such as fertilizers and pesticides, and mounting debts, make it difficult for farmers to increase their productivity. On the other hand, rising fuel and electricity prices have worsened the situation, soaring food prices in the market, and reducing people's purchasing power. Labor issues are also a major obstacle. High labour costs and difficulty accessing experienced workers, especially due to government policies, have led to a decline in productivity at the small farmer level. Meanwhile, weaknesses in marketing structures and export policies have wasted surplus harvests, affecting farmers' incomes and overall food distribution.

Table 6. Challenges Impact on Food Security.

Category	Challenges	Impact on Food Security
Economic	High input costs, debts, rising prices	Limits productivity, increases food prices, and reduces affordability.
Labor	High wages, limited access to cheap labor	Raises production costs, lowers productivity, and reduces food availability.
Market & export	Poor marketing, export restrictions	Causes waste, reduces farmer income, and limits food distribution.
Farming practices	Inefficient methods, unregulated patterns	Decreases productivity, and causes instability in food supply.
Crop diseases	Pests, high pesticide costs	Reduces yield, and increases food shortages due to poor disease management.
Environment	Water shortages, extreme temperatures	Hinders irrigation, reduces yields, and threatens long-term agricultural productivity.
Policy & governance	Weak policies, lack of agricultural support	Reduces market stability and hampers farming modernization.
Social & health	High costs, no health insurance	Strains household finances, limits access to agricultural inputs, and lowers productivity
Conflict	War, disrupted markets	Reduces income, limits market access, and exacerbates food scarcity.

The application of inefficient agricultural techniques and minimal regulation in agricultural patterns have led to production instability, while pest and plant disease attacks have further worsened crop yields. Environmental problems, such as water shortages and damage from extreme temperatures, have hampered irrigation and land productivity in the long term. Lack of government attention to the agricultural sector, including weak export-import policies, has created market instability and reduced agricultural resilience to shocks. At the social level, high education and health costs, without health insurance coverage, have burdened farmers' household finances, reducing investment in the agricultural sector. Furthermore, conflicts such as the wars in Syria and Gaza disrupt distribution channels and market access, worsening food security in an already vulnerable region. From the challenges that have been explained, in this study the researcher also looks at the intersection challenges. **Figure 1** illustrates the intersection of the dominant challenges faced by smallholder farmers in three main dimensions such as environmental, policy and governance, and other economic challenges. The intersection shows how these factors are interrelated and worsen the conditions of smallholder farmers.

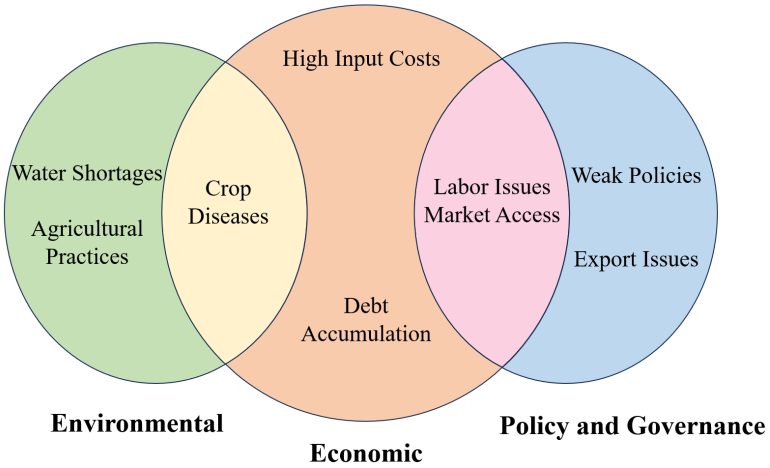

Figure 1. Intersection of Dominant Challenges Faced by Smallholder Farmers.

Sources: Authors' creation.

Farmers in the Middle Jordan Valley face similar challenges to those depicted in the figure. High input prices such as fertilizers, pesticides, and seeds cause production costs to exceed revenues. Crop diseases such as mites, blight, and fusarium also worsen crop yields. In addition, mounting debts from farm supply stores and the need to repay bank loans increase financial pressures. Policy factors pose major challenges, including the closure of export markets due to regional conflicts such as the Syrian war and complex export regulations. Many farmers also feel that the government does not pay enough attention to the agricultural sector, either in terms of financial support or more regular cropping patterns. As a result, farmers often lose markets and suffer significant financial losses. From an environmental perspective, water shortages, extreme cold, and high temperatures further limit agricultural productivity. All of this suggests that overlapping environmental, policy, and economic challenges worsen the situation of farmers in the Jordan Valley.

Environmental challenges are among the major issues facing smallholder farmers[21]. Water shortages and inefficient farming practices have a major impact on the productivity of their land. In addition, plant diseases, often triggered by climate change or poor land management, are also serious threats. Water shortages and pest or disease attacks add to the stress on farmers and often lead to huge losses. On the other hand, weak government policies and governance exacerbate the situation. The lack of support through policies that favor the agricultural sector, such as ineffective export regulations, is a major barrier for farmers[22]. The problem is compounded by limited market access and high labor costs, which often make it difficult for farmers to

sell their crops at a fair price. The combination of these challenges creates a heavy burden for smallholder farmers. For example, the high cost of inputs such as fertilizers and seeds often forces them to go into debt, which in turn increases their accumulated debt. The instability caused by environmental challenges, coupled with unsupportive policies, worsens their economic situation. This makes it increasingly difficult for farmers to access competitive markets, both locally and globally. This result has a similar result with [23].

5.3. Analysing Migration Plans of Smallholder Farmers from Agriculture Activities in The Middle Jordan Valley

Analysing the migration plans of small farmers from the agricultural activities analysed based on the relationship between Push Factors with short-term and long-term consequences can be explained in detail in the form of a mathematical quadrant as presented in **Figure 2**.

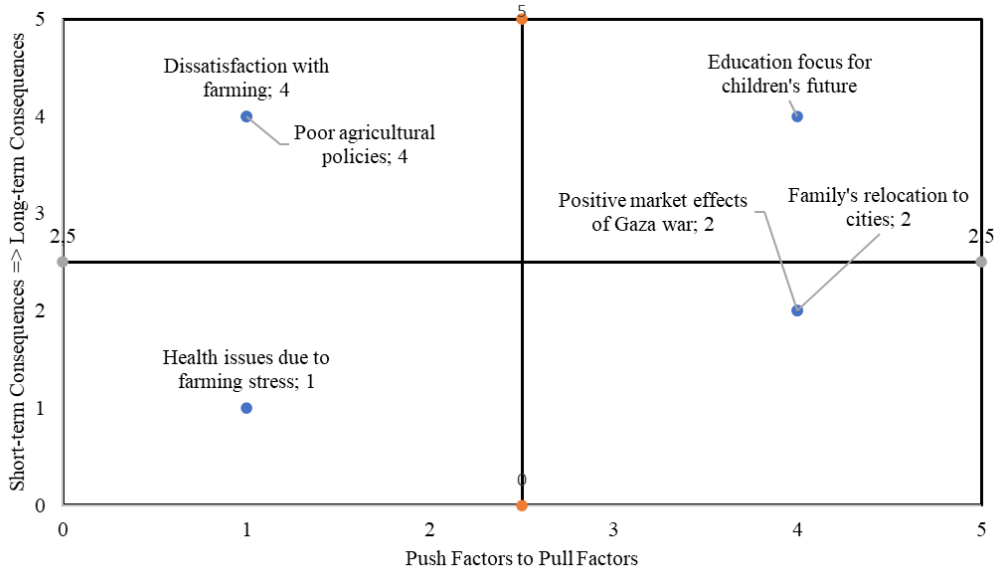

Figure 2. Push and Pull Factors Quadrant Influencing Farming Decisions and Their Consequences.

Sources: Authors' creation.

Quadrant 1 focuses on Push Factors with short-term consequences, which reflect the immediate challenges faced by farmers, such as financial problems, nutritional challenges, and health problems arising from physical and mental stress from working in the agricultural sector. These factors encourage farmers to immediately take mitigation measures, for example by reducing farming activities or switching to other sources of income in nearby cities such as Salt. This condition does not provide an attractive opportunity to survive in the agricultural sector but rather forces farmers to leave this sector to avoid further suffering.

Quadrant 2 describes Push Factors with long-term consequences, showing dissatisfaction with the condition of agriculture, lack of support for the development of this sector, and ineffective agricultural policies create a pessimistic view of the future of this profession. These problems are systemic and long-lasting, so they not only affect current farmers but also erode the interest of the younger generation to continue their livelihoods in agriculture. Thus, the gradual migration of people from farming communities becomes inevitable, because this profession is seen as no longer able to guarantee economic sustainability. Quadrant 1 and Quadrant 2 are not included in Quadrant 3 or Quadrant 4 because the factors identified are driven more by Push Factors, which are negative motivations that encourage individuals to leave the agricultural sector, rather than by Pull Factors that offer positive incentives or better opportunities elsewhere.

Quadrants 3 and 4 are usually related to opportunities such as better access to education, higher-paying jobs, or other positive economic impacts, which are not

found in the context of the problems in Quadrants 1 and 2. Therefore, the factors influencing these farmers are more relevantly placed in Quadrants 1 and 2, reflecting the push to leave the agricultural sector without promising better alternatives. Refer to **Table 7**, which is the concluding table for quadrant analysis.

Table 7. Explaining Table for Quadrant Analysis.

Quadrant	Category	Key Factors	Consequences
Push Factors - Short-term	Financial & Health Challenges	1. Financial and nutritional challenges. 2. Health issues due to farming stress.	1. Immediate hardships leading to reduced farm output. 2. Farmers are driven to seek alternative livelihoods outside agriculture.
Push Factors - Long-term	Systemic Issues	1. Dissatisfaction with farming conditions. 2. Impact of poor agricultural policies.	1. Loss of generational farmers. 2. Decline in agricultural sustainability and resilience.
Pull Factors - Short-term	Urbanization & Immediate Relief	Family relocations to cities for a decent life. Positive market effects of the Gaza war.	1. Quick migration reducing farm labor. Immediate economic relief for families. Increased urbanization pressure on city infrastructure.
Pull Factors - Long-term	Opportunities Abroad	2. Emigration for better opportunities. 3. The desire for better education and jobs for children.	1. Brain drain reducing local expertise and innovation. 2. Weakening community cohesion and loss of farming knowledge.

Table 7 above illustrates the dynamics of push and pull factors that influence farmers' migration from the agricultural sector. Short-term push factors such as financial challenges, nutritional problems, and health problems due to farming pressures push farmers to immediately seek alternatives outside of agriculture, often with the result that it has an impact on the decline in agricultural land productivity. Meanwhile, long-term push factors such as dissatisfaction with farming conditions and ineffective agricultural policies cause the younger generation to lose interest in continuing this profession, which leads to a decline in the sustainability of the agricultural sector. On the other hand, short-term pull factors such as urbanization and market effects due to conflicts such as the Gaza war offer temporary solutions through family migration to cities for decent life conditions, although this puts additional pressure on urban infrastructure. In the long term, opportunities abroad, including better education and jobs, are a big attraction for communities but often have negative impacts in the form of loss of local human resources, innovation, and traditional knowledge in farming communities. The combination of these factors creates a major challenge for the sustainability of the agricultural sector while affecting the social and economic balance of the community. This research supports the research of[24,25]. Therefore, the researcher develops a strategy that the government can implement to maintain the sustainability of agriculture for smallholder farmers in the Middle Jordan Valley in the next section.

The challenges faced by smallholder farmers in the agricultural sector have profound implications for food security, economic stability, and rural livelihoods. These interconnected challenges create a complex web of barriers that exacerbate existing vulnerabilities. High input costs, such as fertilizers and pesticides, have increased production costs, often exceeding revenues. This situation forces farmers to accumulate debt, further exacerbating financial instability. Plant diseases such as mites, leaf blight, and fusarium, exacerbated by inefficient agricultural practices, further reduce yields, making recovery more difficult[21]. At the same time, environmental pressures, including water shortages and extreme temperatures, limit irrigation and long-term land productivity, undermining the sustainability of agricultural practices in regions such as the Central Jordan Valley.

These persistent and overlapping challenges not only threaten immediate agricultural outputs but also ex-

pose deeper structural weaknesses in the livelihood systems of smallholder farmers. To better understand how farmers navigate and respond to these stressors, it is essential to examine the full range of assets and resources they rely on, both tangible and intangible [31]. The SLF provides a comprehensive approach to analysing these dynamics by considering how human, social, natural, physical, and financial capital interact to influence farmers' resilience and adaptive capacity.

The SLF provides a valuable lens to examine the resilience and vulnerabilities of smallholder farmers [32] in the Middle Jordan Valley. In this context, the five livelihood assets, human, social, natural, physical, and financial capital, interact in complex ways to shape farmers' capacity to adapt to challenges such as market volatility and climate extremes. For example, financial capital, such as access to credit or remittances from family members working in cities or abroad, often determines whether farmers can invest in adaptive technologies like greenhouse systems or drought-resistant seeds. Social capital, including kinship networks or local cooperatives, often plays a critical role in facilitating information-sharing, accessing informal loans, or coordinating irrigation during water shortages. These networks can buffer households during crises but may also be strained when entire communities face collective risks such as prolonged drought or price shocks [2].

Human capital, particularly education and health, affects decision-making and labor productivity. Educated household members are more likely to diversify income sources or navigate bureaucratic systems for agricultural subsidies. Natural capital, such as land fertility and water access, is under severe stress due to climate variability, including rising temperatures and irregular rainfall patterns. Degraded land limits productivity and accelerates migration trends. Meanwhile, physical capital, including tools, transport, and irrigation infrastructure, often determines whether smallholders can bring products to market or manage crop cycles efficiently. However, uneven infrastructure development means that not all farmers benefit equally from these assets.

Moreover, food security outcomes are not only technical or economic; they are also deeply social and cultural [27]. In many farming communities in the Jordan Valley, women play crucial but often underrecognized roles in farming labor, household nutrition, and financial decision-making. However, gender norms can limit women's access to land ownership, agricultural training, or formal financing mechanisms. At the community level, cultural expectations around male leadership in decision-making may overlook women's knowledge and capacity to influence agricultural resilience. Thus, addressing food security requires not only improving access to assets but also tackling social structures that shape who benefits from them.

These environmental pressures are largely driven by climate variability. According to [40,42], prolonged droughts such as those experienced in the summers of 2017 and 2021 led to significant crop losses, especially for water-intensive vegetables like tomatoes and cucumbers. Farmers reported up to 40% yield reductions during these dry periods. Flash floods during unusually heavy winters also eroded topsoil and damaged irrigation infrastructure, compounding recovery costs [40]. Such events not only threaten short-term food supply but also deplete long-term soil fertility and discourage replanting, contributing to the decision by many smallholder farmers to abandon cultivation altogether [42]. These climate impacts, combined with policy and economic pressures, create a fragile system increasingly vulnerable to shocks.

Policy and governance issues exacerbate these difficulties. Ineffective agricultural policies, weak market structures, and restrictive export regulations hinder farmers' ability to access competitive markets, both locally and globally. Farmers in the Central Jordan Valley, for example, have experienced significant financial losses due to complex export restrictions and the closure of export markets due to regional conflicts such as the Syrian war [22]. These challenges illustrate how governance deficiencies directly undermine food security by reducing the efficiency of food distribution and agricultural resilience to shocks. Furthermore, the government's lack of financial and logistical support leaves farmers without the tools they need to modernize their practices, deepening their reliance on traditional, often inefficient methods.

Social dynamics also play a significant role in shaping farmers' decisions to stay in or leave the agricultural sector. High education and healthcare costs, coupled with limited access to health insurance, place additional pressure on household finances. The physical and mental stress associated with farming further discourages young people from continuing in the profession. Rising living costs, coupled with economic uncertainty, are driving many farming families to consider migration as a viable alternative. This migration is often driven by short-term financial pressures and long-term dissatisfaction with the state of the sector, leading to a gradual decline in farming across generations. The erosion of community interest in agriculture undermines the sustainability of the sector, creating a cascading effect on food security and rural development [24].

The push and pull factors influencing migration decisions among smallholder farmers are closely linked to their socio-economic realities. Immediate financial and health challenges, as depicted in Quadrant 1, push farmers to scale back their farming activities or shift to alternative livelihoods in nearby urban centres. Over time, systemic issues, such as ineffective agricultural policies and poor sectoral support, foster pessimistic views about the future of agriculture, prompting younger generations to abandon farming altogether. This trend, captured in Quadrant 2, reflects growing disinterest in agricultural careers, which threatens to erode the resilience of rural communities and reduce their economic viability [25–28]. However, these migration patterns are not necessarily irreversible. Empirical evidence and stakeholder interviews suggest that appropriate interventions such as enhancing market access, providing fair input subsidies, improving rural infrastructure, and reforming agricultural policies can significantly alter migration intentions. For instance, farmers who gained access to stable export channels or cooperative-led marketing platforms were more inclined to continue farming. Similarly, youth-focused agricultural entrepreneurship programs have proven effective in other MENA contexts, offering pathways to economic stability within rural areas. These examples indicate that well-targeted interventions could revive interest in agriculture and potentially reverse the outflow of human capital from the sector.

While urbanization and opportunities abroad provide short-term relief and long-term aspirations for better living conditions, they come with significant sacrifices. The migration of farming families to urban areas reduces immediate financial pressures but exacerbates the burden on urban infrastructure [29,30]. Similarly, emigration to pursue better education and employment opportunities abroad often results in brain drain, reducing local expertise, innovation, and traditional agricultural knowledge. These losses weaken community cohesion and undermine the ability of the agricultural sector to adapt to future challenges [31]. To address these challenges, a strategic and holistic approach is essential. Policymakers must prioritize reforms that strengthen agricultural governance, promote efficient agricultural practices, and provide financial support tailored to the unique needs of smallholder farmers.

5.4. Formulating Strategies to Strengthen Food Security for Smallholder Farmers

These challenges smallholder farmers face include environmental pressures such as water scarcity, inefficient irrigation, climate variability, and economic burdens such as high input costs and limited market access. Social factors, including labour shortages and migration, further exacerbate these farmers' vulnerability, making it difficult for them to maintain productive and resilient farming systems. To comprehensively address these issues, strategies must be formulated to strengthen food security while empowering farmers to effectively address these constraints.

An important first step is to address environmental challenges by introducing integrated irrigation systems and promoting environmentally friendly farming practices. Water-efficient irrigation equipment, such drip irrigation, and training on sustainable agricultural methods can help farmers maximise water consumption and boost yields. This strategy guarantees long-term soil fertility, reduces degradation of the environment, and solves water shortages. In addition to these measures, offering accessible educational programs on modern farming techniques can help farmers transition to

more sustainable practices. Policy and governance reforms play a critical role in improving food security for smallholder farmers[32,33]. Simplifying export regulations and providing incentives for export-oriented farmers can open access to competitive markets, allowing farmers to get better prices for their crops. Developing efficient market infrastructure, such as local centres for buying and selling crops, reduces logistics costs and strengthens farmers' presence in markets. This can reduce financial stress and increase profits, as well as encourage reinvestment in modern agricultural technologies.

Economic constraints such as high input costs and reliance on traditional farming methods can be reduced through targeted subsidy schemes and strengthening farmer cooperatives. Providing subsidies for essential inputs such as fertilizers and pesticides reduces production costs and eases the financial burden on farmers. Encouraging farmers to form cooperatives encourages collaboration, allowing them to share resources, pool risks, and increase their bargaining power in the market[34]. To make these recommendations more actionable, it is crucial to outline specific steps for implementation. Strengthening farmer cooperatives, for instance, could begin in the short term with government-sponsored workshops and funding support for initial organization and legal registration. In the medium term, establishing regional cooperative unions can facilitate collective bargaining and bulk procurement of agricultural inputs. Over the long term, cooperatives could evolve into agro-processing entities that add value to farm products, improving income streams for members. Similarly, improving export policies can start with short-term reforms, such as simplifying licensing procedures and reducing paperwork for small-scale exporters. Medium-term steps might include negotiating trade agreements that favor smallholder producers and investing in digital platforms for export information. In the long run, developing cold-chain logistics and quality assurance labs can ensure Jordanian agricultural products meet international standards, making them more competitive in foreign markets.

Such collective efforts also increase their resilience to economic shocks and environmental uncertainties. Social challenges, including youth out-migration and labour shortages, highlight the need for income diversification and skills development programs. Providing non-farm skills training, such as entrepreneurship and information technology, enables farming families to explore additional sources of income. This reduces their dependence on farming alone and provides financial stability during periods of low productivity. This result also supports the research of[35]. By equipping families with new skills, the program also inspires young people to view agriculture as a viable and innovative career option, thereby reducing the long-term decline in the agricultural workforce. Overall, a holistic approach that integrates environmental, economic, policy, and social strategies is critical to strengthening food security for smallholder farmers. By addressing water scarcity, modernizing agricultural practices, reforming governance, and empowering communities through education and collaboration, these strategies can help farmers overcome the challenges they face.

Implementing these strategies requires a phased approach that accounts for the resources, institutional capacity, and socio-political realities in the Central Jordan Valley. In the short term, pilot programs focusing on one or two communities can serve as testing grounds for interventions such as drip irrigation or training in environmentally sustainable practices. Medium-term goals could include scaling up successful interventions regionally and investing in rural infrastructure such as roads and storage facilities. Long-term strategies must prioritize institutional strengthening, sustained financial support, and regional integration, which are essential for maintaining food security under changing climatic and economic conditions. Potential challenges include limited budget allocations, resistance to new technologies among older farmers, and bureaucratic inertia. Addressing these barriers will require cross-sectoral collaboration and active involvement from local communities, private sector stakeholders, and government agencies. To ensure these phased strategies translate into meaningful and lasting outcomes, they must be supported by a coherent and inclusive policy framework that aligns with on-the-ground realities and empowers smallholder farmers through targeted reforms.

In addressing challenges such as water shortages, weak government policies, and high-cost burdens in the agricultural sector, an integrated and applicable policy approach is needed. Proposed policies should prioritize sustainability, farmer empowerment, and strengthening governance systems. For example, the government can develop water-efficient irrigation strategies to address water shortages, combined with education on environmentally friendly agricultural practices to improve resource use efficiency. Furthermore, regulations that support market access, such as eliminating high logistics costs or providing export incentives, can help farmers obtain fairer prices for their crops. Policy support should also include investment in rural infrastructure and agricultural technology to make it easier for farmers to access high-quality inputs at affordable prices. These results have a similar pattern with [2,33–37] to support agricultural conditions in Middle Eastern countries. The government can utilize targeted subsidy schemes to reduce reliance on debt and strengthen the economic position of small farmers. In addition, community-based policies that encourage collaboration between farmers, such as cooperatives, can reduce individual stress and increase global competitiveness (**Table 8**).

Table 8. Strategies to Strengthen Food Security.

Category	Recommendations	Practical Implementation
Environmental Challenges	Development of advanced irrigation practices and environmentally friendly farming practices.	Building water-efficient irrigation systems and providing training on sustainable modern agricultural techniques.
Policy & Governance	Reforming export policies and strengthening access to local markets.	Offering tax incentives for export-oriented farmers and developing efficient market infrastructure.
Intersection of Challenges	Provision of agricultural input subsidies and strengthening farmer cooperatives.	Providing direct subsidies for fertilizers and pesticides, as well as facilitating the establishment of cooperatives.
Social & Economic	Income diversification programs and new skill education for farming families.	Organizing training in non-agricultural skills, such as entrepreneurship and information technology.

6. Conclusions

The average size of owned private land was 28.31 dunams, and, this limited land availability combined with scarce resources such as water and a high dependency on agriculture elevates the risk of household-level food insecurity. Jordanian smallholder farmers continue to face persistent challenges, including high input costs, crop diseases, growing debt burdens, and restrictive export policies, many of which are compounded by regional instability. Water scarcity and extreme climatic conditions further constrain agricultural productivity, exacerbating their economic vulnerability. This study applied the Sustainable Livelihood Framework (SLF) as a comprehensive analytical tool to explore how livelihood assets, agricultural practices, and migration decisions interrelate in the Middle Jordan Valley. Through the integration of economic, environmental, and policy aspects, the SLF facilitated the identification of the main challenges influencing food security and assisted in the development of focused, situation-specific strategies. The analysis revealed two main trajectories influencing farmers' migration: Quadrant 1 reflects short-term push factors such as financial strain, nutrition deficiencies, and health issues; Quadrant 2 indicates long-term dissatisfaction driven by poor agricultural conditions and inadequate policy support, particularly among younger generations. To sustain agricultural livelihoods in the region, several strategic recommendations were proposed, including the adoption of water-efficient irrigation technologies, environmentally sustainable farming practices, export policy reform, improved access to local markets, input subsidies, stronger farmer cooperatives, and income diversification programs. Implementing these recommendations will require a phased approach beginning with localized pilot programs, followed by infrastructure development, and eventually institutional reform while anticipating challenges such as limited funding, technological resistance, and bureaucratic inertia. Ultimately, enhancing food security in the Middle Jordan

Valley depends not only on local interventions but also on stronger collaboration with government bodies and international organizations. Such partnerships are essential for shaping more responsive and inclusive agricultural policies that address the root causes of vulnerability and ensure long-term resilience for smallholder farmers in the region.

Author Contributions

A.G. led the conceptualization, methodology design, software development, and validation of the study. R.M.N. was actively involved in conducting the formal analysis, managing the investigation process, gathering resources, and curating the data. Meanwhile, A.A.A.-A. provided critical support by reviewing and refining the manuscript, developing visual representations, and overseeing the project to ensure its successful completion. All authors have read and agreed to the published version of the manuscript.

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This research is conducted without any external source of funding. All activities related to the study, including data collection, analysis, and reporting are self-funded by the researcher. Despite the absence of financial support, the study is designed to maintain academic rigor and ethical standards, ensuring that the quality and integrity of the research are not compromised.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data supporting the findings of this study are not publicly available due to privacy/ethical restrictions.

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Conflicts of Interest

The authors declare no conflict of interest.

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