Research on World Agricultural Economy
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REVIEW

Reviewing Agricultural Challenges and Solutions for Empowering Smallholders in the Middle East

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ABSTRACT

Smallholder agriculture is vital in rural livelihoods, managing up to 75% of the world's agricultural land. However, in the Middle East, smallholder farmers face complex interrelated challenges, most notably climate change, water and irrigation, and economic pressures. These factors mutually exacerbate and increase the vulnerability of smallholder farmers, reducing productivity, yield stability, and lack of access to nutritious food, especially for vulnerable groups. Previous research has focused on individual challenges and region-specific data, leaving little room for comprehensive insights into the interactions between these factors. This study aims to analyse the interrelated challenges faced by smallholder farmers in the Middle East, quantify their impact on food security and livelihoods, and propose sustainable strategies to improve agricultural resilience and sustainability. The method used was a systematic review, following relevant guidelines such as PRISMA to ensure a transparent and rigorous process. The results showed that Iran and Saudi Arabia contributed the largest data. The main challenges are low irrigation system efficiency, rising input costs, and limited access to agricultural innovations. These challenges impact five livelihood assets: human, physical, social, financial, and natural, collectively affecting food security. The analysis shows the need for collaboration between the agriculture and technology sectors, including using AI-based applications and hardware to improve production efficiency, manage water, and reduce costs. Recommendations include integrating government policies, field practices, and new technologies as key to better food security, and training farmers in utilizing agricultural innovations for sustainable livelihoods in the region.

Keywords: Challenges; Food Security; Livelihood Assets; Middle East; Smallholder Farmers

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ARTICLE INFO
Received: 20 January 2025 | Revised: 21 January 2025 | Accepted: 13 February 2025 | Published Online: 28 July 2025
DOI: https://doi.org/10.36956/rwae.v6i3.1688

CITATION
Ghanayem, A., Nor, R.M., 2025. Reviewing Agricultural Challenges and Solutions for Empowering Smallholders in the Middle East. Research on World Agricultural Economy. 6(3): 668–689. DOI: https://doi.org/10.36956/rwae.v6i3.1688

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1. Introduction

Smallholder agriculture plays a critical role in the livelihoods of rural populations worldwide [1,2]. Smallholder farmers manage up to 75% of the world's agricultural land. Smallholder farmers in the Middle East also face significant challenges related to food security [3–5]. The conditions of smallholder farmers in the Middle East demonstrate their vulnerability to environmental and economic challenges concerns due to external shocks [6], similar to those experienced by smallholder farmers in South Africa, but in a context that is more influenced by limited natural resources, especially water, and dependence on sustainable irrigation [7,8]. This research draws on theories emphasizing the interconnectedness of climate change, resource management (especially water and irrigation), and the economic challenges smallholder farmers face. These factors exacerbate each other's impacts and increase farmers' vulnerability, threatening their food security and livelihoods.

Given their limited natural resources, smallholder farmers face significant water shortages in many countries in the Middle East, such as Saudi Arabia, Jordan, and Egypt [9–11]. Much of the region is arid or semi-arid, with very low rainfall and a reliance on irrigation for agriculture. This severely limits their capacity to produce food sustainably and increases their vulnerability to climate change, such as prolonged droughts and reduced water resources. Climate change also significantly impacts smallholder farmers in the Middle East. Smallholder farmers in the Middle East are highly dependent on unpredictable rainy seasons, and greater fluctuations in rainfall patterns affect their yields. Smallholder farmers in the Middle East often have limited access to modern agricultural technologies, capital, and training [12]. This leaves some countries in the Middle East heavily dependent on food imports to meet domestic needs [13]. This makes them more vulnerable to global market shocks, including the impacts of climate change in other countries that could reduce global food supplies or increase food prices.

The agricultural sector in the Middle East is both a cornerstone of the regional economy and a critical component of food security. Despite its importance, the sector faces significant challenges due to limited natural resources, such as land and water, and reliance on traditional farming practices, which hinder productivity and sustainability. From the data found from FAO and World Bank [14,15], these challenges are compounded by the varying scales of agricultural operations across the region, from smallholder farms in countries like Egypt to larger-scale operations in nations such as Saudi Arabia. While domestic production contributes to meeting local consumption needs, as seen in Iran, where 70% of food demand is met locally, the heavy reliance on food imports which exceeds 80% in Saudi Arabia and the UAE highlights the region's vulnerability. These dynamics underscore the relevance of the agricultural sector to global Sustainable Development Goals (SDGs), particularly SDG 2 those related to food security, natural resource management, and improving people's well-being. One of the most relevant SDGs is SDG 2, Zero Hunger, which aims to end hunger and ensure access to sufficient and nutritious food for all. Smallholder farmers in the Middle East, who rely heavily on agricultural output to feed themselves, face significant challenges due to climate change, water scarcity, and dependence on irrigation [16,17]. Given the limited natural resources and increasing demand for food in a rapidly developing region, these challenges threaten their food security. Therefore, examining the challenges faced by smallholder farmers in the Middle East in the face of climate change and pressures on agricultural output is critical to achieving SDG 2. The challenges faced by smallholder farmers in the Middle East can be understood through the lens of the Sustainable Livelihoods Framework (SLF), which highlights the interplay between five key assets human, natural, financial, social, and physical affected by vulnerabilities such as climate change, economic instability, and limited policy support. Applying SLF allows this research to systematically evaluate the interconnected challenges while identifying strategies to improve resilience.

The Sustainable Livelihoods Framework (SLF) serves as a critical lens for analysing the challenges faced by smallholder farmers in the Middle East, yet its application needs further elaboration. SLF highlights five livelihood assets such as human, physical, social, financial, and natural that collectively determine farmers' resilience and adaptive capacity. Climate change, water scarcity, and economic stress impact these assets

in interconnected ways. For example, climate variability leads to reduced agricultural productivity (natural asset), which in turn affects household income (financial asset) and limits access to farming inputs such as irrigation technology (physical asset). Water scarcity exacerbates the crisis by restricting irrigation and reducing soil quality, further limiting agricultural output. In addition, economic pressures, such as high input costs and volatile market conditions, undermine farmers' ability to invest in modern agricultural techniques, leading to long-term financial instability. The interplay among these factors creates a cycle of vulnerability that makes smallholder farmers increasingly dependent on external support, such as government subsidies or social capital (social asset), to survive. Strengthening this section by explicitly linking each challenge to SLF will enhance the analytical depth of the study. Furthermore, the study integrates insights from climate-resilience theories, emphasizing adaptive capacity and sustainable resource management, and systems theory, which addresses the dynamic and interdependent nature of agricultural challenges in the Middle East.

In addition, SDG 6, Clean Water and Sanitation is also relevant as many countries in the Middle East experience significant water shortages, which have a direct impact on agricultural productivity [18,19]. Smallholder farmers, who rely on limited water resources, need to adopt more efficient water management methods to ensure the sustainability of their farming operations [18,19]. Therefore, to improve the welfare of smallholder farmers and achieve related SDGs, it is important to conduct an in-depth study of their challenges and find sustainable solutions to overcome these obstacles. Smallholder farmers in the Middle East face a range of interrelated challenges that not only exacerbate each other but also significantly impact agricultural productivity and sustainability [20–22]. This undermines food security, particularly among vulnerable populations with limited access to nutritious food [23]. While there is some research in this area, understanding how these challenges interact and impact smallholder farmers' livelihoods is limited. Much of this area's research is based on limited data, often covering only a single region or country. This study seeks to fill this gap by using broader, more representative data and examining the variation in challenges faced by smallholder farmers across the Middle East in more depth. While individual challenges such as climate change or economic pressures have been studied, there is a lack of research examining how these factors interact and exacerbate their impacts in the context of smallholder farming in the Middle East.

This study aims to analyse the interrelated challenges faced by smallholder farmers in the Middle East, quantify their impact on food security and livelihoods, and propose sustainable strategies to improve agricultural resilience and sustainability. The study will contribute to evidence-based policymaking, by providing recommendations that can address the specific needs of farmers and enhance their ability to adapt to environmental and economic changes.

2. Materials and Methods

2.1.Materials and Method

The literature selection process in this study was carried out systematically by following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards to ensure transparency and reliability of the results [24,25]. Literature data were obtained from two main databases, namely Scopus (n = 2783) and Google Scholar (n = 99), using the search keywords: ("livelihood" OR "income" OR "subsistence" OR "economic") AND ("assets" OR "resources" OR "capital" OR "wealth") AND ("smallholder" OR "small-scale" OR "family" OR "farmers") AND ("agriculture" OR "farming" OR "cultivation" OR "production") AND ("Middle East" OR "Arab" OR "region" OR "countries") AND ("sustainability" OR "resilience" OR "socioeconomic" OR "socio-economic").

The initial stage involved the removal of 58 duplicate literatures. After that, an initial screening process was carried out through four stages, namely the first screening by country/region limited to Middle Eastern countries (n = 97), the second screening by relevant keywords (n = 70), the third screening by document type (n = 68), and the last screening by subject area (n = 58).

After the initial screening stage, the remaining articles were further evaluated using Rayyan software for the second stage of selection. The second stage of screening in a systematic review is needed to ensure that the selected literature is truly relevant and meets

the inclusion criteria [26–28]. The methodology section mentions the use of PRISMA for systematic review, but further details on the inclusion and exclusion criteria are necessary to ensure transparency. This study selected literature based on relevance to smallholder farming challenges in the Middle East, with criteria including empirical research, regional focus, and recent publication (preferably within the last decade). Studies lacking sufficient methodological details or focusing solely on large-scale commercial agriculture were excluded. Furthermore, to minimize selection bias, the review process incorporated a two-stage screening approach, first filtering by keywords and relevance, followed by full-text evaluation using Rayyan. Rayyan offers a structured and semi-automated review process, enabling a more objective and systematic selection of relevant articles while reducing human bias. Unlike traditional manual screening, Rayyan's machine-learning-assisted categorization allows for more efficient data processing and ensures consistency in article selection. Expanding this explanation will improve the methodological rigor of the study. This stage involves evaluating the full text of the articles, so that articles that do not sufficiently support the research objectives can be excluded, for example, due to lack of data, inappropriate methods, or irrelevant topics. This process also helps reduce bias, optimize the final results, and improve the quality of the systematic review [29]. The results of this stage of selection resulted in 38 reports being included in the final review. A total of 20 reports were excluded from the review for several reasons, namely the report did not provide enough information to be included, the report was not publicly accessible, the report was deemed not to meet the criteria based on the title and abstract, or the report did not meet the criteria after full-text evaluation. For further explanation, see the following **Figure 1**.

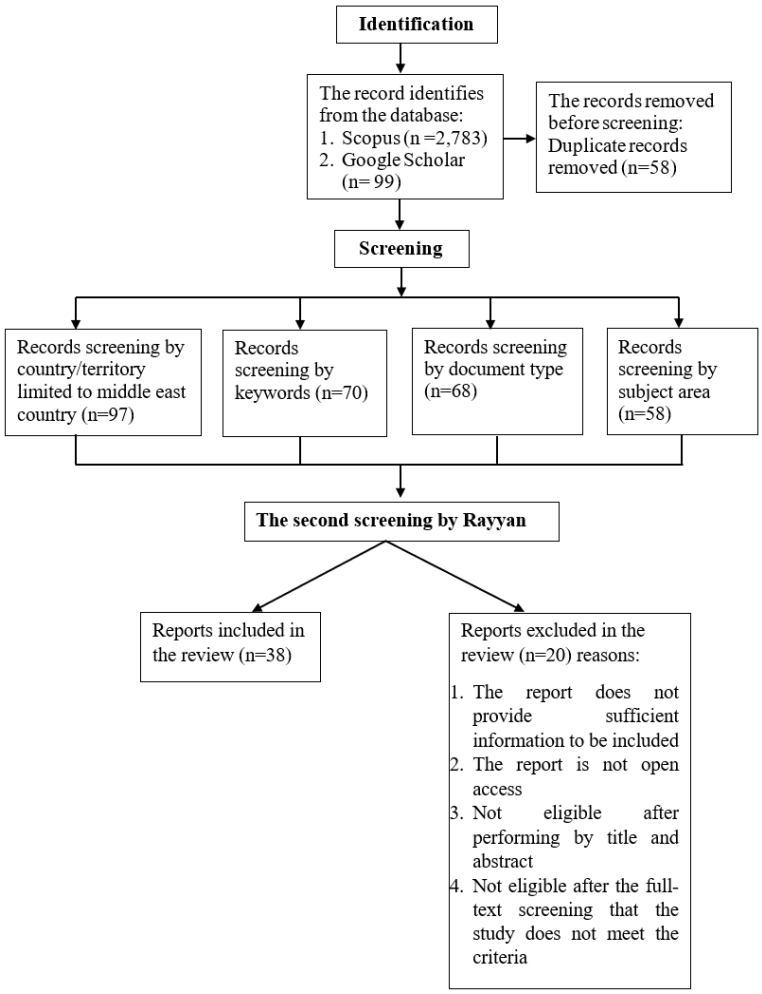

Figure 1. Flow diagram of the literature screening process.

Sources: Authors Creation.

2.2.Data Synthesis

After the initial screening stage, the remaining articles were further evaluated using Rayyan software for the second stage of selection. The second stage of screening in a systematic review is needed to ensure that the selected literature is truly relevant and meets the inclusion criteria [30,31]. This stage involves evaluating the full text of the articles, so that articles that do not sufficiently support the research objectives can be excluded, for example, due to lack of data, inappropriate methods, or irrelevant topics [32,33]. This process also helps reduce bias, optimize the final results, and improve the quality of the systematic review. The results of this stage of selection resulted in 38 reports being included in the final review. A total of 20 reports were excluded from the review for several reasons, namely the report did not provide enough information to be included, the report was not publicly accessible, the report was deemed not to meet the criteria based on the title and abstract, or the report did not meet the criteria after full-text evaluation. For further explanation, see **Figure 2**.

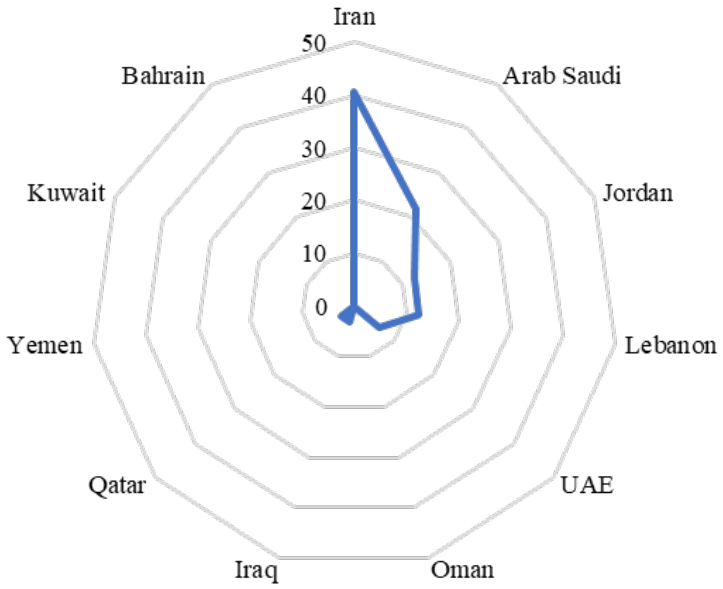

Figure 2. Countries contributing to research on challenges and strategies for smallholder farmers in the Middle East.
Sources: Scopus database.

3. Results

This result provides information about challenges followed by interconnected challenges faced by smallholder farmers in the Middle East, and Unraveling the Effects of Agricultural Challenges on Smallholders' Livelihoods and Food Security.

3.1.Challenges Faced by Smallholder Farmers in the Middle East

It is seen that research on the challenges faced by smallholder farmers in the Middle East is dominated by contributions from Iran with a percentage of 41%. This shows that Iran has a very high interest in smallholder issues, which may be related to the high population of smallholder farmers in the country and the dependence of the agricultural sector on certain geographical and climatic conditions. As one of the countries with a large and varied territory, research in Iran tends to highlight efforts to overcome the agronomic, economic, and social challenges faced by smallholder farmers.

Saudi Arabia came in second with a contribution of 22%. The focus of research in Saudi Arabia is likely to be on the unique challenges faced by smallholder farm-

ers in desert areas, including water availability, food security, and adoption of technologies to improve agricultural efficiency in harsh environments. The country is also increasingly investing in the development of its agricultural sector to support economic diversification away from oil. Jordan and Lebanon each contributed 13%. In Jordan, water scarcity and rapid urbanization are likely to be the main topics of research, while in Lebanon the focus may be more on the political, social, and economic challenges affecting the lives of smallholder farmers, especially in the context of regional conflict and instability [33]. The contributions of countries such as the United Arab Emirates (UAE) at 6%, and Iraq and Qatar at 3% each, indicate that despite their smaller contributions, research from these countries is still significant, especially in the context of technological innovation and modern agricultural policies. On the other hand, not all countries in the Middle East such as Oman, Yemen, Kuwait, and Bahrain showed or had any contribution to this study as no literature was found from these countries, which may reflect the lack of focus on smallholder farmers' challenges or different research priorities in these countries. Overall, this distribution reflects the differences in research priorities in each country, driven by the diverse geographical, social, economic, and political conditions in the Middle East.

The study highlights research contributions from different Middle Eastern countries, but lacks a comparative analysis of agricultural challenges across these regions. While Iran and Saudi Arabia have the highest research contributions, other countries such as Jordan, Lebanon, and the UAE face distinct agricultural constraints that warrant further examination. A cross-country comparison would enhance the study's depth by identifying key differences in irrigation efficiency, policy support, and climate resilience measures. For example, while Saudi Arabia has invested heavily in desalination and hydroponic farming, Jordan struggles with severe water scarcity and limited policy interventions to support smallholder farmers. Iran, on the other hand, experiences a unique combination of climate-related stress and economic sanctions that limit farmers' access to resources. Including a table comparing agricultural productivity, water access, and government support across different Middle Eastern countries would provide a clearer understanding of the region's diverse challenges.

The combination of contributions from countries with high attention such as Iran and Saudi Arabia, as well as from other countries, provides a more comprehensive insight into the challenges of smallholder farmers in the region. The **Figure 3** below illustrates the main challenges faced by smallholder farmers in the Middle East, focusing on eight categories of challenges. Climate change (20%), water and irrigation (18%), and economic challenges (17%) are the three biggest challenges affecting the sustainability of the agricultural sector in the region [34]. These challenges illustrate the complexity of agriculture, which is highly dependent on weather, water access, and economic stability [35].

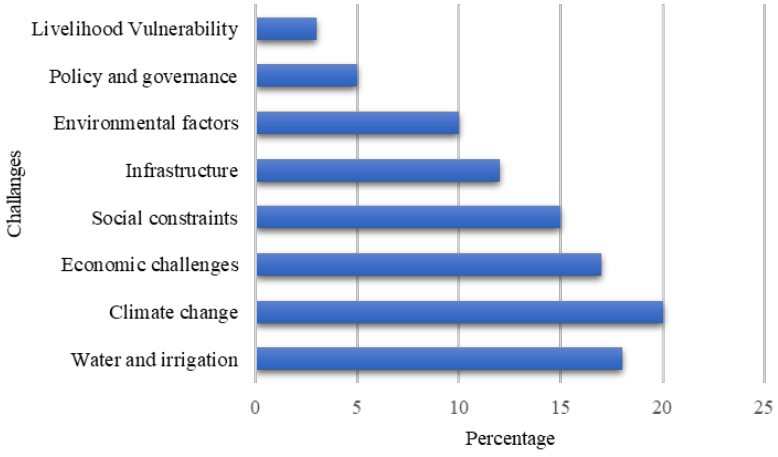

Figure 3. Percentage of analysed paper about challenges faced by smallholder farmers in the Middle East.

Sources: Authors' creation.

Climate change is the biggest threat due to rising temperatures, erratic rainfall patterns, and the intensity of extreme weather events, resulting in reduced yields and increased risk of crop failure [36]. In the Middle East, a predominantly desert and high-temperature region, climate change has a direct impact on land productivity and increases the need for adaptive solutions, such as better water resource management and the use of drought-resistant crop varieties. The second challenge is water and irrigation. With only 1% of global freshwater available to the Middle East and North Africa region, water scarcity is a major constraint. Many smallholder farmers do not have access to efficient irrigation, leaving them highly dependent on erratic rainfall. Better water management policies, including investment in modern irrigation technologies such as drip irrigation, can help optimize water use in the region. Economic challenges, including high costs of inputs such as fertilizers and pesticides, and dependence on agrochemical companies, are another barrier for smallholder farmers. Low farm incomes often make it difficult for them to invest in technologies or practices that can improve productivity. To address this, governments can provide subsidies or incentives for smallholder farmers to reduce their production costs.

In addition to the three main challenges, five other challenges also affect smallholder farmers in the Middle East. Social constraints (15%) include low levels of education, an aging farming population, and limited social networks [37]. These limit farmers' ability to adopt new technologies or access wider market opportunities. Training and education efforts for smallholder farmers can help build their capacity. Infrastructure (12%) is a constraint due to the lack of rural infrastructure, including poor road access and competition for land use. This hinders the distribution of crops and access to markets. Investment in rural infrastructure is essential to reduce this gap. Environmental factors (10%) such as soil degradation due to excessive use of chemical fertilizers and unsustainable farming practices further impair productivity. Solutions such as crop rotation and the use of organic fertilizers can help maintain soil fertility. Policy and governance (5%) reflect weak supportive agricultural policies, including minimal extension services for smallholder farmers. More inclusive agricultural policy reforms and adequate service delivery can improve their productivity. Livelihood vulnerability (3%) describes farmers' sensitivity to climate risks and economic pressures that force migration to other areas. Support for livelihood diversification can help smallholder farmers increase their resilience to these challenges.

These challenges are explained in more detail in the description summarized in **Figure 4** below. The challenges faced by smallholder farmers in the Middle East are complex and interrelated. One of the main constraints is related to access to water and irrigation. The drastic decline in groundwater levels and changes in rainfall patterns due to erratic monsoon seasons make irrigation expensive and unreliable [38]. In addition, the continued decline in water quality due to the use of agrochemicals worsens the sustainability of agriculture. Existing irrigation systems are also inefficient because the adoption of water-saving technologies, such as drip irrigation, is still low [39–41]. This is due to high costs, technological complexity, and lack of incentives. In addition, flood damage is a serious threat due to the lack of adequate drainage systems and preparation for extreme weather.

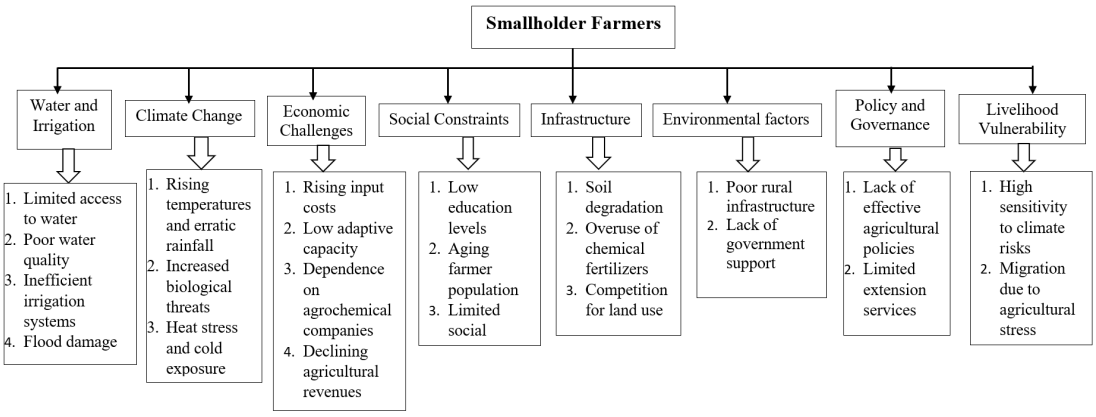

Figure 4. Further explanation of challenges faced by smallholder farmers in the Middle East.

Sources: Authors' creation.

3.2.Interconnected Challenges Faced by Smallholder Farmers in the Middle East

Figure 5 below illustrates the interrelated challenges faced by smallholder farmers across three main categories which are Climate Change, Water & Irrigation, and Economic Challenges [42]. Each circle represents a challenge within a category, with overlapping areas showing how these factors interplay and exacerbate the difficulties faced by smallholder farmers. Smallholder farmers face the impacts of climate change such as rising temperatures, unpredictable rainfall patterns, and biological threats such as increased pests and plant diseases. These factors not only shorten the growing season but also increase the risk of crop failure, which directly impacts food security [43,44]. Limited water availability, poor water quality due to agrochemical pollution, and inefficient irrigation systems are major barriers to ensuring sustainable yields. In addition, flood damage is common due to a lack of drainage systems and disaster preparedness, exacerbating farmers' vulnerability to extreme weather events. As for economic challenges, smallholder farmers face rising costs of inputs such as seeds, fertilizers, and irrigation equipment, which are often unaffordable. Low incomes from agriculture drive many farmers to seek employment outside agriculture. Reliance on profit-oriented agrochemical companies also complicates the adoption of sustainable agricultural practices [45,46].

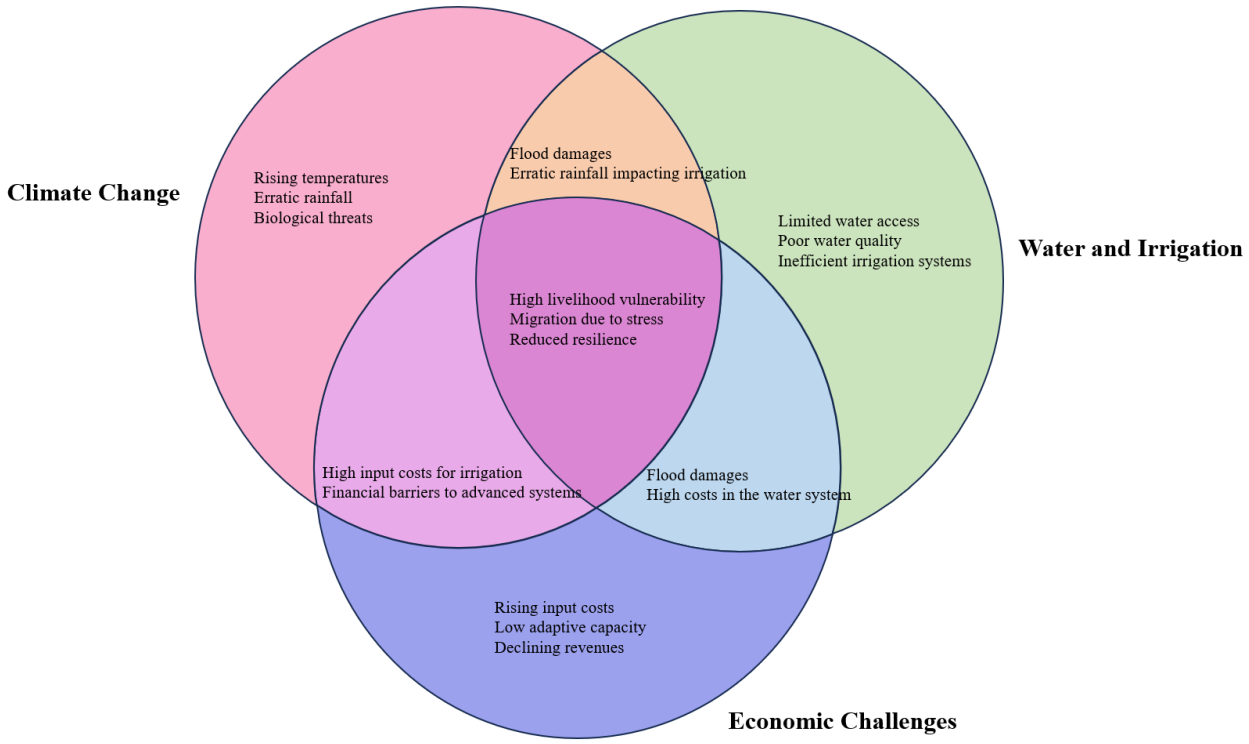

Figure 5. Interconnected challenges faced by smallholder farmers in the Middle East.

Sources: Authors' creation.

3.3.Unraveling the Effects of Agricultural Challenges on Smallholders' Livelihoods and Food Security

The challenges faced by smallholder farmers in the Middle East can be grouped into five livelihood asset categories: human assets, physical assets, social assets, financial assets, and natural assets. Each category has specific constraints that affect the sustainability of their livelihoods and food security in the region. A further explanation is shown in **Table 1** below.

Table 1. Challenges and impacts on food security across livelihood assets.

Asset	Challenges	Impact on Food Security
Human [20, 37, 45–53]	1. Limited education and training on modern farming methods. 2. Aging farmer population. 3. Limited awareness and adaptive capacity for climate change impacts.	1. Reduces farmers' ability to adopt innovative and sustainable practices, decreasing agricultural productivity and resilience. 2. Declines in labour efficiency and productivity, with limited transfer of knowledge to younger generations. 3. Farmers are less equipped to respond to climate shocks, resulting in lower yields and potential crop failures.
Physical [21, 40, 41]	1. Destruction of infrastructure due to floods. 2. Inadequate irrigation systems and falling groundwater levels. 3. Limited access to advanced agricultural technologies. 4. Overreliance on agrochemical companies.	1. Disrupts farming activities, transportation of goods, and access to markets, leading to reduced food availability and affordability. 2. Limits water availability for agriculture, reducing crop yields and increasing dependence on imported food. 3. Hinders productivity gains and the ability to mitigate the effects of adverse climatic conditions. 4. Increases production costs, reducing farmers' profitability and ability to invest in sustainable practices.
Social [16, 38, 39, 43, 44, 54]	1. Limited social networks for innovation adoption. 2. Inconsistent public extension services. 3. Rural isolation and lack of access to markets.	1. Restricts knowledge-sharing and collective problem-solving, leaving farmers isolated in adapting to challenges. 2. Deprives farmers of reliable sources of guidance, reducing opportunities to enhance productivity and adopt climate-resilient techniques. 3. Reduces income opportunities for farmers and limits the availability of diverse and affordable food for urban populations.
Financial [19, 24, 47, 48, 55, 56]	1. High cost of agricultural inputs and declining profitability. 2. Limited capacity to recover from extreme weather events. 3. Insufficient government support.	1. Deters farmers from investing in productivity-enhancing measures, leading to stagnation or reduction in food production. 2. Prolong recovery periods after disasters, reducing overall agricultural output and increasing vulnerability to food shortages. 3. Leaves farmers vulnerable to market volatility and unable to sustain production during crises.
Natural [19, 21–23; 25, 34, 35, 57, 58]	1. Degraded land quality. 2. Reduction in rainfall and extreme weather events. 3. Increased biological threats (e. g. , pests, diseases).	1. Reduces arable land, leading to lower agricultural yields and reliance on imports to meet food demand. 2. Intensifies water scarcity, disrupts planting cycles and contributes to crop losses, destabilizing food availability and affordability. 3. Further reduces crop productivity, leading to higher food prices and limited access to nutritious food, especially for vulnerable populations.

In the context of human assets, based on literature the low level of education of farmers, an average of only 3.74 years of schooling, is a major obstacle. This limited education hinders their ability to adopt innovative and sustainable agricultural practices [47], which ultimately reduces the productivity and resilience of the agricultural sector to environmental change [48,49]. Lack of training in modern agricultural methods, including flood control techniques [50], further exacerbates the situation, resulting in decreased labour efficiency and difficult transfer of knowledge to younger generations [51]. In addition, other workers reaffirmed their research that aging farming populations, such as sheep and goat farmers in Jordan, make them more vulnerable to climate shocks and crop failures, which directly impact agricultural yields [34].

Physical assets also present a major challenge, namely infrastructure damaged by floods, such as irrigation channels, roads, and pumping stations, hampered the availability of water for agriculture and reduced crop yields. Inadequate irrigation, coupled with declining groundwater levels and insufficient rainfall, limited farmers' efforts to increase productivity. Low awareness and capacity to adapt to climate change made it difficult for farmers to maintain their agricultural activities, which ultimately reduced local food

availability and encouraged dependence on imports. Social assets reflect limitations in network support and collaboration [59]. Dependence on agrochemical companies for agricultural input supplies often limits knowledge sharing and collective problem-solving. Farmers become isolated in the face of challenges, especially among vulnerable households [35]. Limited social support, coupled with inconsistent public extension services, means that much of the education and training is outsourced to more profit-oriented private companies. This limits income-generating opportunities for smallholder farmers and reduces affordable food diversity for urban populations.

In the financial assets category, key challenges include rural isolation that reduces access to markets and innovation, and high costs of agricultural inputs such as fertilizers, pesticides, and irrigation systems [60]. This limited access discourages farmers from investing in productivity-enhancing measures. Decreased crop profitability also makes farmers vulnerable to market volatility and prolongs recovery time after disasters, resulting in lower agricultural output and increased risk of food shortages [54]. Natural assets are also under significant pressure. Deteriorating land quality due to salinity, desertification, and excessive use of chemical fertilizers reduces agricultural productivity [61].

4. Discussion

4.1. Interconnected Challenges and Resilience Pathways for Smallholder Farmers in the Middle East

The challenges faced by smallholder farmers in the Middle East reflect the complex interplay of climatic, economic, and social factors unique to the region. Research contributions on this topic were dominated by Iran, which accounted for 41% of the studies, likely due to the country's significant smallholder population and its reliance on agriculture in a variety of geographic and climatic conditions. The focus in Iran included addressing the agronomic, economic, and social constraints that hinder smallholder farming. Saudi Arabia, which contributed 22% of the studies, emphasized pressures specific to desert environments, such as air scarcity, food security, and the adoption of efficient technologies to support agricultural productivity under difficult conditions [36,42,62]. Other countries, such as Jordan and Lebanon, each contributed 13%. Jordanian research often highlighted air scarcity and rapid urbanization, while Lebanese studies focused on the political and economic instability affecting smallholder farmers, especially in conflict-affected areas. In contrast, countries such as the UAE, Iraq, and Qatar contributed fewer but valuable insights into technological innovation and modern agricultural policies.

Climate change is a major challenge, affecting 20% of the studies described. Rising temperatures, unpredictable rainfall, and extreme weather events threaten agricultural productivity, with smallholder farmers particularly vulnerable to crop failure and reduced yields. In largely arid regions, climate change exacerbates existing air scarcity issues, necessitating adaptive measures such as drought-tolerant crops and better management of air resources. Water and irrigation challenges, addressed in 18% of the studies, are particularly important as the region's access to fresh water is limited to just 1% of the global supply. Many farmers rely on inefficient irrigation systems or uneven rainfall, highlighting the urgent need to invest in modern irrigation technologies such as drip irrigation. Economic challenges, accounting for 17%, stem from high costs of inputs such as fertilizers and pesticides, limited access to capital, and dependence on profit-focused agrochemical companies. These economic constraints hamper smallholder farmers' ability to adopt sustainable practices and technologies, making government subsidies or financial incentives crucial to improving productivity [43–46].

Social, infrastructural, environmental, and policy factors compound the difficulties faced by smallholder farmers. Social constraints, including limited education, an aging farming population, and weak social networks, hinder the adoption of innovative practices and limit market access [16,54]. Poor rural infrastructure, such as inadequate roads and competing land uses, create logistical barriers to crop distribution [43,44]. Environmental challenges, including soil degradation

caused by unsustainable farming practices, reduce long-term productivity and require solutions such as crop rotation and organic fertilizers [21–24]. Weak agricultural policies and limited extension services further limit smallholder farmers' access to the support and resources they need to thrive. Livelihood vulnerability, although rarely mentioned (3%), highlights precarious farmers, who face pressure to migrate due to climate risk and economic instability. Addressing these challenges requires a holistic approach, combining rural investment, training, and policy reforms to strengthen resilience and productivity.

These challenges are closely interconnected, as illustrated by the overlapping nature of climate change, water scarcity, and economic hardship. The interdependence of these factors creates a feedback loop in which one challenge feeds into another. The systematic review highlights several critical challenges faced by smallholder farmers in the Middle East, as evidenced by the literature. Many of the cited references predate 2023, necessitating the integration of more recent studies to reflect the latest advancements in agricultural resilience. Recent research on food security in the Middle East emphasizes the impact of global conflicts, such as the Russia–Ukraine war, on agricultural input costs and supply chain disruptions [6]. Additionally, studies on AI-driven precision farming highlight the potential for technology to optimize resource use and improve smallholder productivity [36]. Efforts to adapt to climate change in the Gulf Cooperation Council (GCC) countries increasingly involve aligning environmental goals with economic diversification plans [62], highlighting the importance of integrating climate policies into long-term development strategies. Similarly, research on sustainable agriculture in the UAE [63] offers insights into policy-driven initiatives that could serve as models for other Middle Eastern nations.

Climate change exacerbates vulnerabilities due to erratic rainfall patterns, directly impacting crop yields [19]. For instance, prolonged droughts and extreme heat in Jordan and Lebanon have led to significant declines in agricultural productivity and increased crop failure risks [37], severely reducing crop viability and emphasizing the urgent need for drought-resistant crops and sustainable farming practices. Water scarcity remains a dominant constraint, with inefficiencies in irrigation systems and overreliance on groundwater reducing agricultural productivity [16,39]. In Saudi Arabia, such challenges have been shown to significantly affect food security [37], reinforcing the need for tailored water management strategies. Economic barriers further complicate the adoption of modern agricultural technologies, particularly in low-income communities in Iran [19]. For instance, prolonged droughts and extreme heat in Jordan and Lebanon have led to significant declines in agricultural productivity and increased crop failure risks [37], severely reducing crop viability and emphasizing the urgent need for drought-resistant crops and sustainable farming practices. Additionally, the review underscores the impact of degraded natural resources, as excessive agrochemical use in Iraq has led to declining soil quality and reduced arable land [47,55]. Social isolation also poses significant challenges; weak extension services and limited networks hinder knowledge sharing and innovation among farmers, particularly in rural Jordan [35,52]. These findings collectively underscore the interconnected nature of these challenges and the need for integrated solutions.

4.2.Strategies to Overcome Challenges Faced by Smallholder Farmers

Climate change is worsening the situation with rising temperatures and unpredictable rainfall patterns, resulting in shorter growing seasons and a higher risk of crop failure. In addition, biological threats such as increased pest attacks, plant diseases, and invasive weeds are becoming more frequent [32]. Livestock is also not spared, as livestock experience heat stress and exposure to extreme cold, which increases mortality rates. Economically, smallholder farmers face significant pressures due to rising prices of agricultural inputs such as seeds, fertilizers, and irrigation equipment, which narrow profit margins. Their adaptability is also low due to limited access to resources such as credit, land, and technology [33]. Dependence on profit-oriented agrochemical companies also complicates efforts towards sustainable agriculture. In addition, declining incomes from the agricultural sector have forced many

smallholder farmers to seek employment outside the agricultural sector to meet their household needs. From a social perspective, the low level of education with an average of only 3.74 years of schooling is a major challenge in introducing modern agricultural techniques [34]. The farming population dominated by the elderly also hinders regeneration, as the younger generation is less interested in entering the agricultural sector due to the lack of incentives and educational opportunities. In addition, limited social capital among marginal farmers with small networks means they lack the financial and emotional support to adopt innovations [35,37]. Infrastructure in rural areas is often in poor condition. Roads, irrigation channels, and agricultural tools are inadequate or even damaged, as in Iraq [38]. Lack of government support is also a major obstacle, where public investment in the agricultural sector continues to decline, making farmers increasingly vulnerable to market fluctuations and climate risks [39]. Environmentally, land degradation is a serious problem with issues such as salinity and desertification that reduce land productivity. Excessive use of chemical fertilizers not only pollutes the environment but also damages soil health in the long term. In addition, competition for land use to meet food needs and environmental sustainability goals creates a dilemma, especially for small farmers with limited land. These challenges are further exacerbated by ineffective policies and governance. Trade policies often flood local markets with imports, undermining local agricultural production. The lack of public extension services also hampers farmers' capacity to adopt sustainable agricultural practices [40,41]. As a result, smallholder farmers are highly vulnerable to climate, economic, and social risks. Many are forced to migrate or diversify their livelihoods, further weakening rural communities. All of these challenges highlight the urgent need for holistic and sustainable solutions to support smallholder farmers in the Middle East.

These compounding issues not only threaten the livelihoods of smallholder farmers but also intensify the challenges posed by climate change. At the intersection of Climate Change and Water & Irrigation, challenges such as flood damage and changing rainfall patterns are placing additional pressure on water resources. Erratic rainfall patterns are exacerbating the problem of water availability for irrigation. This water shortage is compounded by the lack of adoption of modern irrigation technologies such as drip irrigation. At the intersection of Climate Change and Economic Challenges, farmers struggle to manage the additional costs of biological risks, such as pests and diseases caused by climate change. The high cost of modern irrigation technologies and the lack of government subsidies limit farmers' ability to adopt more efficient solutions. At the intersection of Water & Irrigation and Economic Challenges, low irrigation system efficiency and rising input costs are compromising farmers' ability to adapt to increasingly difficult situations. Finally, at the midpoint, these three factors are mutually reinforcing, leading to significant vulnerability. Smallholder farmers are becoming more vulnerable to financial, social, and biological stresses, reducing their ability to cope and adapt. The combination of these three factors creates a vicious cycle that makes smallholder farmers even more vulnerable, especially in managing climate, water, and financial risks simultaneously. In addition, other challenges such as biological threats, including pest attacks, plant diseases, and invasive weeds, worsen the situation. On the other hand, reduced rainfall in terms of quantity, frequency, and quality described in the literature, as well as the increasing threat of extreme weather events such as floods and droughts, make it increasingly difficult for farmers to maintain a stable cropping cycle. Reliance on limited government subsidies and loans also hampers their ability to recover from shocks [56]. According to observations that have been made in previous studies, all of these challenges have a direct impact on food security. To address these issues, several strategies have been designed and implemented with an integrated and contextual approach (**Table 2**).

Table 2. Proposed strategies from analysed references to address challenges faced by smallholder farmers.

Category	Strategies
Water issues [22, 25, 59, 60]	1. Adoption of modern irrigation systems (drip and sprinkler system) 2. Improved water management and monitoring.
Climate Change [21, 23, 34, 35]	1. Promotion of climate-smart agriculture. 2. Sustainable land and water management practices.
Economic Challenges [16, 24, 61, 64]	1. Financial support through subsidies and credit facilities. 2. Expanding crop insurance mechanisms. 3. Enhancing value addition and processing.
Social Constraints [21, 37, 38, 63]	1. Strengthening public extension services. 2. Promoting community-based approaches. 3. Encouraging youth involvement in agriculture.
Infrastructure [21, 47, 65– 67]	1. Investment in resilient infrastructure. 2. Use of treated and recycled water for irrigation.
Environmental Factors [19, 47, 48, 57, 58]	1. Rehabilitation of degraded ecosystems. 2. Focus on low-input agriculture. 3. Addressing soil and water salinity.
Policy and Governance [68–71]	1. Designing localized agricultural policies. 2. Incentivizing environmentally sustainable practices. 3. Expanding extension services and governance.
Livelihood Vulnerability [17, 66, 72–78]	1. Crop diversification to manage risks. 2. Support for smallholders' resilience during crises. 3. Mitigating reliance on non-farm activities.

In addressing the problem of water and irrigation constraints, the adoption of modern irrigation systems such as drip irrigation and sprinklers is a key step. This strategy is complemented by training and demonstrations to ensure farmers understand how to operate and maintain the technology [57]. In addition, rainwater harvesting and the use of recycled water for irrigation are important solutions to reduce dependence on conventional water sources, especially in areas prone to drought [58]. Planting crops that require less water is also a priority, along with the implementation of more efficient water management and the introduction of virtual water trading to support sustainability. In the face of climate change, promoting climate-smart agricultural practices is a key solution suggested in studies. This includes the introduction of drought-tolerant crop varieties, soil mulching techniques, and capacity-building programs to help farmers adapt to temperature and rainfall variability. Sustainable land and water management is also encouraged through organic practices, reducing the use of chemical fertilizers that can accelerate land degradation [59].

From an economic perspective, financial support such as subsidies, low-interest credit, and agricultural insurance are increasingly being expanded to protect farmers from losses due to extreme weather, pests, or market fluctuations [57]. These efforts are accompanied by the promotion of added value through agricultural processing and the introduction of technologies that increase product competitiveness in the market. Product diversification and mechanization are also carried out to extend shelf life and increase farmer productivity [61]. Then, to address social barriers, governments, and local organizations are strengthening public extension services by reaching out to smallholder farmers, and providing education on climate-resilient agricultural practices [64]. Community-based approaches are also being adopted to foster collaborative networks and innovation among farmers. In addition, youth engagement in agriculture is being focused on through incentives such

as mentorship programs, to ensure the sustainability of the sector in the future [65].

Infrastructure deficiencies, such as damaged irrigation systems and limited road access, are addressed through significant investments in disaster-resilient infrastructure. Developing technology transfer facilities in rural areas and using recycled water for irrigation are also part of this strategy. These steps help ensure that farmers have better access to the resources and technologies needed to increase agricultural yields [66,67]. From an environmental perspective, rehabilitation of degraded ecosystems is carried out through sustainable grazing policies and natural resource conservation programs [68,69]. Reducing dependence on chemical fertilizers, along with the introduction of salinity-tolerant crops, helps address the challenges of soil and water degradation [70]. Policy support also plays an important role as discussed in the research. Agricultural policies tailored to local needs, incentives for environmentally friendly practices, and transparent and extensive public services are the foundation for building a more equitable and efficient system. Crop diversification is also encouraged to reduce reliance on monoculture systems, strengthen farmers' resilience to climate risks, and improve food security at the local level [71,72].

Finally, there are some efforts to address the livelihood vulnerability of smallholder farmers in the region. One of the main strategies is crop diversification, which aims to reduce the risk of crop failure by encouraging farmers to grow a variety of crops, both seasonal and perennial. This approach allows farmers to not only rely on one type of crop but also creates a more diverse farming system that is resilient to climate change and market price fluctuations. In addition, to support the resilience of smallholder farmers during the crisis, it is important to develop food security policies that focus on increasing local production. This policy aims to reduce dependence on imports so that smallholder farmers can be more self-sufficient in dealing with external pressures such as global supply disruptions. Various literature supports the importance of this strategy, including studies conducted [73–76], which emphasize the need for an integrated approach to increasing the resilience of smallholder farmers to global and regional challenges.

Addressing the intertwined challenges faced by smallholder farmers requires a holistic approach that combines innovation, policy reform, and capacity building. One of the most critical issues is water scarcity, which can be mitigated through the adoption of modern irrigation systems such as drip and sprinkler irrigation. These technologies have been shown to optimize water use, particularly in arid regions like Saudi Arabia and Jordan, where water resources are scarce [16,37]. Rainwater harvesting and recycling initiatives could complement these efforts, reducing dependency on groundwater while building resilience against erratic rainfall patterns. However, implementing these solutions requires not only financial support, such as subsidies but also hands-on training programs to ensure farmers can effectively adopt and maintain these systems [19,39]. Climate-smart agricultural practices must also play a central role in improving productivity and sustainability [77,78]. Drought-resistant crop varieties, combined with techniques such as mulching and soil moisture conservation, have been identified as key strategies in Lebanon and other Middle Eastern countries facing extreme weather conditions [19,47]. These practices not only enhance crop yields but also safeguard natural resources from degradation. To encourage widespread adoption, government and private sector collaboration is essential. Policies that incentivize farmers to transition to environmentally sustainable methods, alongside extension services that provide technical guidance, can bridge the gap between innovation and implementation [39, 55].

Economic barriers, particularly the rising costs of inputs like seeds, fertilizers, and irrigation equipment, continue to hinder progress. Expanding financial support mechanisms such as low-interest loans and crop insurance schemes can alleviate these pressures [19,46]. Smallholder farmers in low-income regions, like rural Iran, would greatly benefit from such interventions, enabling them to invest in advanced technologies without risking financial instability. Additionally, promoting value-added activities, such as on-farm processing and local marketing, could diversify income sources, allowing farmers to capture greater market value while

reducing reliance on volatile global supply chains [46,55]. Equally important is the social dimension of agricultural resilience. Many smallholder farmers face isolation due to limited access to networks and weak extension services, as observed in Jordan and Oman [35,52]. Community-based initiatives can address these gaps by fostering collaboration among farmers and creating opportunities for knowledge-sharing and collective problem-solving. For instance, farmer cooperatives or digital platforms for peer-to-peer training can enhance access to technical expertise and market information. Engaging younger generations is also crucial. Incentivizing youth participation through mentorship programs, financial support, and career development pathways can rejuvenate the sector, ensuring its long-term viability [33,44]. Lastly, improving infrastructure remains a cornerstone of any strategy to support smallholder farmers. Poor road conditions, inadequate storage facilities, and outdated irrigation systems create significant barriers to productivity and market access. Investments in rural infrastructure, such as all-weather roads and efficient transport networks, can reduce post-harvest losses and improve the competitiveness of smallholder farmers in regional and international markets [39,46]. Similarly, sustainable land management practices, including reforestation and using organic fertilizers, can combat soil degradation and restore the natural resource base critical to agricultural productivity [16,55].

4.3. Strengthening Smallholder Farmers' Resilience Through Sustainable Agricultural Solutions

The findings reveal that the overlapping challenges of climate change, water scarcity, and economic pressures exacerbate the financial instability of smallholder farmers in the Middle East. Erratic rainfall patterns have increased the reliance on costly irrigation systems [16], while reduced water availability has driven up the prices of agricultural inputs [19]. Furthermore, the aging farming population, particularly in Lebanon, has diminished resilience in rural communities by limiting generational knowledge transfer and reducing labor availability [47,34], thereby weakening long-term sustainability. This trend, coupled with a lack of training opportunities, stifles agricultural innovation and calls for targeted youth engagement programs.

Weak governance structures and institutional fragmentation have also constrained the availability and effectiveness of agricultural extension services [39,52], with countries like Yemen and Oman notably lacking localized policy frameworks to support smallholder farmers.

Additionally, degraded soil quality resulting from salinity and the excessive use of agrochemicals has severely reduced agricultural productivity [55], forcing many communities to rely on external markets and increasing their vulnerability to global price fluctuations [46].

To effectively address the intertwined challenges faced by smallholder farmers, a multi-pronged approach is essential. Climate-smart agricultural practices must form the foundation of resilience strategies. For example, drought-tolerant crop varieties have been shown to enhance resilience in arid and semi-arid regions [19], while water-efficient techniques such as drip irrigation systems help optimize limited water resources [16]. These innovations can significantly reduce vulnerability to erratic rainfall and water scarcity. In regions like Jordan and Lebanon, these approaches not only mitigate risks but also enhance the stability of agricultural yields, ensuring a reliable food supply even during climatic disruptions [7]. Equally important is the focus on social and financial empowerment. The aging farming population, particularly in rural Lebanon [47], highlights the need to engage youth in agriculture through mentorship programs and incentives that make farming a viable and attractive livelihood option. Alongside this, improving access to affordable credit and subsidies for farming technologies has been identified as a key strategy to alleviate financial constraints and stimulate innovation among smallholder farmers [34]. This dual focus on human and financial assets can foster a new generation of farmers equipped to face modern challenges.

The degradation of natural resources, particularly soil quality, is another pressing concern that demands immediate attention. The overuse of agrochemicals has degraded soil quality and reduced agricultural pro-

ductivity in Iraq and other parts of the Middle East [55], leaving large areas of farmland increasingly unproductive. Sustainable land management practices, such as organic fertilization and crop rotation, can restore soil health while reducing dependence on external inputs. These practices not only enhance productivity but also align with global calls for environmentally sustainable agriculture. Policy and governance reforms are vital to bridging the gaps in agricultural support systems. Weak governance has resulted in limited access to agricultural extension services and inadequate infrastructure, hindering the ability of smallholder farmers to improve productivity and resilience [39]. For instance, localized policies tailored to the unique challenges of regions such as Yemen and Oman can ensure that training programs and subsidies reach even the most marginalized farming communities [63]. A more inclusive governance structure can amplify the voices of smallholder farmers by integrating their perspectives into policy-making processes, ensuring that their needs and contributions are recognized in national and regional policies [52]. Finally, the role of technology cannot be overstated. Precision farming tools and AI-based applications, while underutilized in many parts of the Middle East [19,46], hold the potential to revolutionize smallholder agriculture. Farmers can optimize resource use, improve productivity, and reduce costs if can integrate technology into farming practices. Collaboration between governments and private sectors is essential to make these technologies accessible and affordable, particularly for low-income farmers in regions like Iran and Saudi Arabia.

The implications of the challenges faced by smallholder farmers in the Middle East region underscore the need for a holistic and sustainable approach to addressing issues in the agricultural sector. Migration and livelihood diversification by smallholder farmers in response to economic and climate pressures not only weaken rural communities but also create greater social challenges, such as reduced regeneration of young farmers and reduced social cohesion. Future research should prioritize the development of policies that support the social and economic stability of smallholder farmers, including subsidies for sustainable agricultural technologies, investments in education and training, and rural infrastructure development. Governments should play a more active role by allocating budgets for agricultural extension services, encouraging the adoption of environmentally friendly agricultural practices, and strengthening local market links to protect farmers from import competition. In addition, sustainability-oriented solutions in the agricultural sector should include efficient natural resource management, crop diversification, and the integration of agroecological systems to enhance food security. Research can guide innovative policies that not only empower smallholder farmers but also strengthen the sustainability of agriculture in the region by addressing these challenges holistically.

5. Conclusions

The research is dominated by two main fields, namely Agricultural and Biological Sciences (53%) and Social Sciences (47%), with the largest contributions coming from Iran and Saudi Arabia. The challenges faced by smallholder farmers in the Middle East are complex, especially those related to climate change, water and irrigation, and economic challenges, which exacerbate each other and increase their vulnerability. This leads to decreased productivity, unstable harvests, and higher food prices, impacting vulnerable groups who have difficulty accessing nutritious food. Ultimately, food security in the region depends largely on addressing challenges in each livelihood asset category with innovative, inclusive, and sustainable solutions. This study aims to identify these challenges, analyse their interrelationships, uncover how they affect smallholder farmers' livelihoods, and develop strategies that can help address them, to improve sustainability and food security in the region, despite the limited contributions from some countries such as Oman, Yemen, Kuwait, and Bahrain. For future recommendations, this study should expand its scope to include under-researched Middle Eastern countries such as Oman, Yemen, Kuwait, and Bahrain, to more fully capture the challenges of smallholder farmers across the region. The conclusion effectively summarizes the study's findings but needs to more explicitly highlight its unique contributions.

This study differentiates itself by offering a systematic review that synthesizes agricultural challenges across the Middle East, rather than focusing on isolated case studies. Unlike previous research that examines individual constraints such as climate change or economic stress, this study presents a holistic view of how these factors interact within the SLF framework. Furthermore, the study's integration of PRISMA and Rayyan enhances methodological transparency, setting a precedent for future systematic reviews in agricultural research. Emphasizing these contributions will reinforce the study's significance. Additionally, further research could assess the potential for collaboration between the agriculture and Agri-tech sectors to develop more inclusive and friendly solutions for smallholder farmers. This collaboration could include training on how to leverage AI-based applications and hardware that can help improve agricultural yields and water management while reducing production costs. Integration of government policies, field practices, and emerging technologies could be key to achieving greater food security in the future. The recommendations currently focus on broad solutions, such as integrating AI and government policies, but would benefit from concrete implementation strategies. Drawing from global best practices, the study could propose targeted subsidies for smart irrigation systems, similar to those implemented in Israel, which have significantly improved water-use efficiency. Additionally, public-private partnerships could facilitate access to climate-smart agricultural technologies, following the example of the UAE's Agri-tech initiatives. Addressing financial barriers, a structured microcredit program tailored for smallholder farmers could provide the necessary capital to adopt modern farming techniques without excessive debt burdens. Policymakers should also consider implementing knowledge-sharing platforms that connect farmers with research institutions, allowing them to access real-time data on soil conditions, weather patterns, and market prices.

Author Contributions

A.G. was responsible for conceptualization, methodology, software development, validation, formal analysis, investigation, resources, data curation, and writing the original draft. R.M.N. contributed by reviewing and editing the manuscript, creating visualizations, and providing supervision throughout the project. All authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Ethical review and approval were waived for this study because it did not involve any intervention, experimentation, or procedures that posed risk to human participants. The study relied on voluntary survey responses, interviews, and group discussions conducted with informed consent, and no sensitive or personal health data were collected.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. Participants were informed about the purpose of the research, and their participation was voluntary. Anonymity and confidentiality were maintained throughout the data collection and reporting process.

Data Availability Statement

The data supporting the findings of this study are not available due to confidentiality and ethical restrictions.

Acknowledgments

The authors would like to express their sincere gratitude to all participants who generously gave their time and insights for this study. We also thank those who provided administrative and logistical support during the data collection process, as well as the community leaders and institutions who facilitated access

to respondents and supported the smooth implementation of this research.

Conflicts of Interest

The authors declare no conflict of interest.

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