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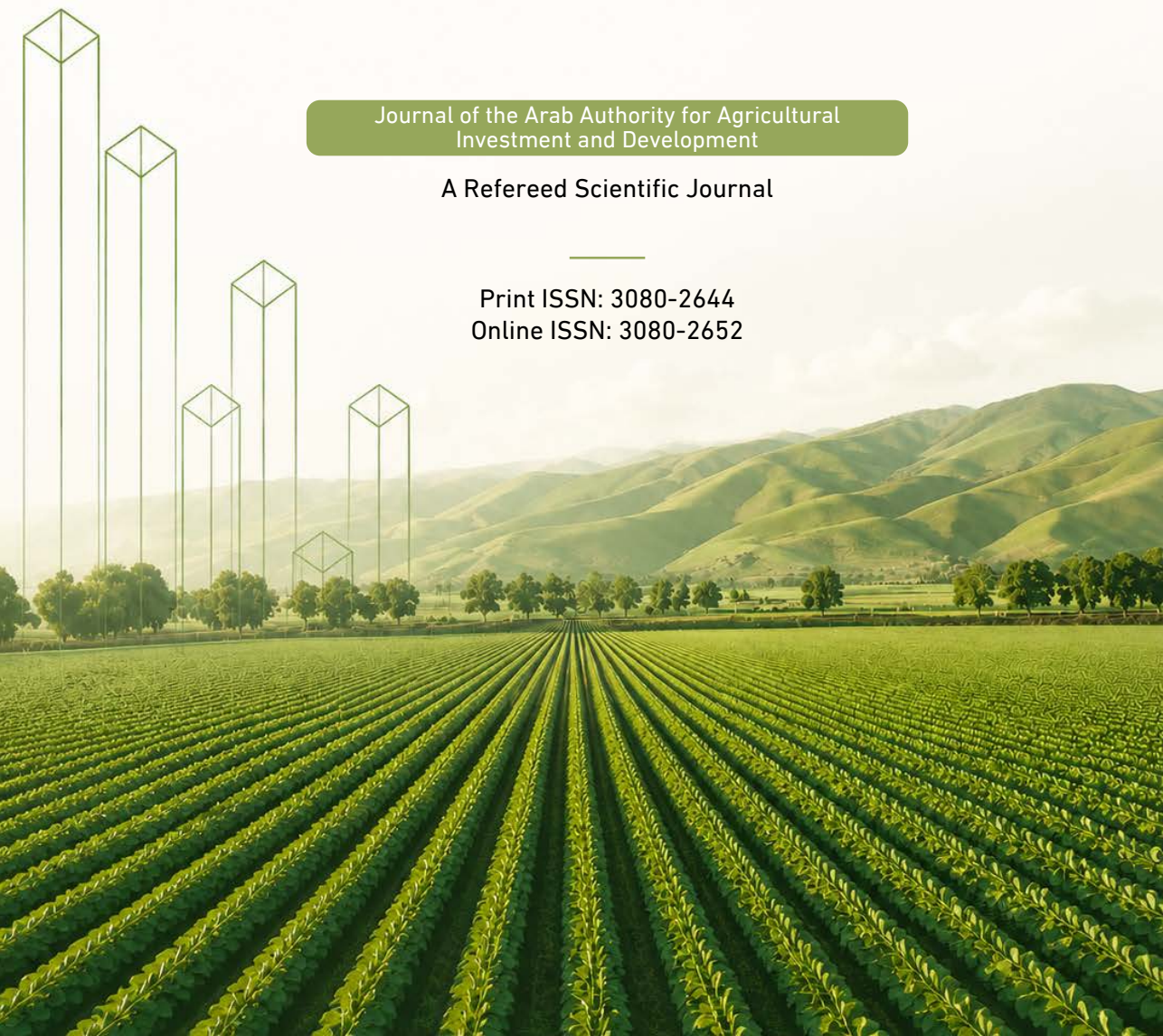
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Financing Resilience: Closing the Arab Food Gap through Innovation and Policy

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Abstract:

Achieving sustainable food security in the Arab world requires mobilizing financial resources, advancing agricultural innovation and creating resilient market structures that reduce the region's dependence on imports. Despite agriculture's role in employment and rural livelihoods, the sector remains underfinanced, with SMEs, which are critical actors in production, processing and distribution, facing systemic barriers to capital access. Our paper aims to demonstrate that identifying and scaling innovative financial models, channeling investment into high-impact technologies, and fostering enabling policies are important steps toward closing the Arab food gap and securing sustainable agricultural development.

Our paper is structured around three interrelated pillars. First, an examination of high-impact innovations that can be financed and scaled across Arab economies. These include strategies and technologies to overcome land and water scarcity, manage pests, and improve productivity for key commodities in the Arab region. We focus on solutions where capital deployment can drive both regional food security and broader economic gains, from employment to trade balance improvements.

Second, an overview of innovative financial models that can unlock agricultural investment, including blended finance, digital financial tools, and outcome-linked financing that ties financial characteristics to measurable improvements in agricultural

production. Such instruments can de-risk investment and align incentives across key stakeholders, including businesses, policymakers, and investors.

Third, an analysis of enabling systems that encourage adoption and scale. This involves regulatory frameworks, shock-responsive financing models to mitigate climate and geopolitical disruptions and public-private partnerships that pool resources while reducing risk exposure. Comparative lessons, such as Asia's food security crisis response framework, highlight how strategic reserves and coordinated supply management can stabilize prices and supply in times of crisis.

By integrating financial innovation with agricultural modernization, we outline a pathway that Arab policymakers and financiers can adopt to build resilient food systems, support SME growth and ensure agriculture becomes a driver of long-term economic resilience.

Key Words: Food Security, Agricultural Innovation, Climate Resilience, Policy Reform, Public-Private Partnerships

Introduction:

Food security in the Arab region is increasingly under strain from structural vulnerabilities, climate change, and global market volatility. The region exhibits structurally high dependence on imports to meet its dietary needs, with imported grains representing roughly 40% of dietary energy and 63% of protein (Rahimi et al., 2023). Long-term empirical evidence confirms that import dependence is not cyclical but structural, with demand for imported food in Arab economies remaining inelastic to price and income shocks, reinforcing vulnerability to external supply disruptions (Mohammed & Almojel, 2025). The human impact of these vulnerabilities is stark. In 2021, an estimated 53.9 million people in the Arab region experienced severe food insecurity, representing a 55% increase since 2010, while more than half the population, approximately 162.7 million people, could not afford a healthy diet (FAO, 2024).

Despite these challenges, agriculture remains a cornerstone of rural livelihoods and employment. Small and medium-sized enterprises (SMEs) account for over 90% of businesses in the Arab world, serving as a major source of job creation and income generation (ANND, 2021). Yet the sector is chronically underfinanced. In the Gulf

Cooperation Council (GCC), SME lending averages just 3% of total bank lending, with an estimated credit gap of USD 250 billion, while in other emerging markets SME lending typically accounts for 15–20% of bank portfolios (OECD, 2025; Deloitte, 2022). This financing shortfall constrains investment in productivity-enhancing technologies and limits the sector's ability to adapt to climate and market risks.

The Arab region therefore faces a dual challenge: reducing its structural dependence on food imports while modernizing agricultural systems to withstand climate and geopolitical shocks. Climate-driven water scarcity is expected to materially constrain agricultural productivity, with rising temperatures and shifting precipitation patterns increasing the incidence of water stress across cropping systems (He & Rosa, 2023). Land degradation compounds these risks, with approximately 46 million hectares of agricultural land, or two-thirds of the region's degraded land, affected by salinization, erosion, and unsustainable farming practices (FAO, 2017).

Addressing these challenges requires an integrated approach that accelerates the adoption of innovative agricultural technologies, mobilizes both public and private finance, and strengthens enabling policy and market systems. This paper argues that aligning capital flows with transformative agricultural solutions, supported by robust governance, can reduce import dependency, enhance resilience, and unlock broader socio-economic benefits for the Arab region.

Literature Review

Food security challenges in the Arab region

Historically, the Arab region's food security has been shaped by structural constraints like limited arable land, chronic water scarcity, and rapid urbanization, combined with policy choices that favored food import reliance over domestic production. Studies consistently link the region's limited natural resources and high import dependence to heightened exposure to external shocks, particularly in grain markets central to caloric intake (Rahimi et al., 2023; Le Mouël et al., 2023). The 2007–2008 food price crisis and subsequent volatility exemplified this vulnerability to external forces, causing a deterioration in household welfare and fiscal balances. The United Nations Economic and Social Commission for Western Asia (ESCWA) underscores that

these long-standing constraints, coupled with fragmented value chains and weak storage and logistics, have kept the region off track on food security and nutrition targets despite periods of strong economic growth (ESCWA, 2023). Climate stressors, including heat, drought and erratic rainfall, contribute to reducing yields and straining groundwater, while salinization and land degradation hinder productivity gains (FAO, 2017; ESCWA, 2019). Recent global shocks, including COVID-19 and the war in Ukraine, exposed the limits of the import-reliant model, tightening cereal supplies and raising prices, with measurable impacts on affordability and diet quality across the region (FAO, 2024; ESCWA, 2023).

The cumulative effect is a persistent vulnerability where global market volatility translates quickly into domestic food stress, with disproportionate impacts on low-income communities given the inelastic nature of food demand. Despite policy efforts such as subsidy reforms, targeted safety nets, and investments in irrigation, progress has been uneven, and nutrition outcomes have stagnated or worsened for many populations (FAO, 2024). The literature converges on the need for systemic reforms: diversified import sources and regional reserves, climate-smart production and water-saving technologies, stronger storage and logistics, and social protection that cushions shocks while enabling dietary adequacy (FAO, 2017; ESCWA, 2023).

Agricultural Innovation and Climate Resilience

Technological innovation in the Arab region has largely focused on water efficiency, climate-smart production, and post-harvest management, reflecting structural constraints of scarce arable land and chronic water stress. Policy frameworks such as the Arab Strategy for Sustainable Agricultural Development (2020–2030) have emphasized precision irrigation, drought-tolerant varieties, protected agriculture, and improved storage and logistics (AOAD, 2020; FAO, 2017). Regional initiatives and knowledge programs such as webinars, capacity-building, and toolkits have aimed to create awareness about climate-resilient practices and share best-fit technologies across contexts (FAO, 2023; ESCWA, 2019). In parallel, global literature on climate-smart agriculture (CSA) highlights integrated solutions (soil health, water management, pest control, and digital advisory) as more effective than single interventions, a principle increasingly reflected in Arab policy discourse (World Bank, 2022; FAO, 2017).

Several efforts show measurable success when finance, extension, and market linkages are aligned. Morocco's Green Plan paired subsidies for drip irrigation with concessional finance, expanding micro-irrigation adoption, improving water-use efficiency, and raising yields in horticulture (FAO, 2017). Jordan, Egypt, and Morocco have advanced PPPs that improved water efficiency, piloted wastewater reuse for agriculture, and reduced post-harvest loss through logistics and cold-chain investments, illustrating the role of private capital and operational know-how in scaling innovation (IWMI, 2024). More broadly, targeted adoption of protected agriculture (greenhouses and net-houses), solar-powered pumping, and improved storage has reduced vulnerability to heat and erratic rainfall, with knock-on benefits for income stability and food availability (FAO, 2017; ESCWA, 2019).

Yet the literature also documents a pattern of partial or unsustainable adoption when enabling systems are weak. Financing constraints, high upfront costs, limited collateral, and banks' risk perceptions slow uptake of CSA technologies, especially among SMEs and smallholders (ESCWA, 2023). Fragmented extension services and insufficient data (weather, soils, market prices) undermine the return on precision tools, while energy and maintenance costs limit the viability of greenhouse and irrigation investments without reliable infrastructure or subsidies (FAO, 2017; ESCWA, 2019). Climate shocks and conflict disrupt supply chains and service provision, causing projects to stall once donor support ends, echoing findings that innovation must be bundled with training, infrastructure, and coherent policy incentives to be durable (World Bank, 2022; FAO, 2024). Overall, the evidence points to a clear conclusion: successful innovation in the Arab region depends on integrated packages and long-term financing mechanisms that de-risk adoption, rather than standalone technologies introduced in isolation (ESCWA, 2023).

Financing Gaps and Agricultural Investment

Although the financing gap for agricultural SMEs in the Arab region has been well documented, efforts to address it through targeted investments have produced mixed results. Donor-backed and multilateral programs have played a central role in attempting to expand access to credit and strengthen rural livelihoods. For instance, the International Fund for Agricultural Development's (IFAD) rural development projects in

Morocco, Sudan, and Yemen combined microfinance with technical assistance, improving household incomes and women's participation, though their benefits often diminished once external funding ended (IFAD, 2022). Similarly, World Bank credit lines in Egypt and Tunisia improved access to irrigation and mechanization but faced uneven repayment rates, reflecting the high-risk nature of agricultural lending (World Bank, 2020). UNDP's blended finance pilots further demonstrated the potential to mobilize private capital, though their success depended heavily on supportive regulatory frameworks (UNDP, 2025).

Complementary mechanisms such as credit guarantees have also been introduced to reduce banks' exposure to agricultural lending. The African Guarantee Fund and regional development banks piloted such schemes in North Africa, modestly expanding SME loan portfolios. However, uptake was slower than anticipated, as financial institutions continued to perceive agriculture as a high-risk sector despite the presence of risk-sharing instruments (ESCWA, 2024). These experiences highlight the structural reluctance of banks to engage with agriculture, even when innovative financing tools are available.

The outcomes of these initiatives underscore a consistent lesson: finance alone is insufficient. Programs that integrated credit with training, infrastructure, and policy reform achieved more durable results, while credit-only schemes often collapsed once donor support ended. Morocco's *Green Plan* (2008–2020) is frequently cited as a successful example, combining subsidies for drip irrigation with concessional loans to significantly improve water-use efficiency and yields (FAO, 2020). By contrast, initiatives in fragile states that lacked complementary support mechanisms struggled to achieve lasting impact. Together, these findings suggest that closing the financing gap requires not only innovative financial models but also systemic reforms that strengthen the enabling environment for agricultural SMEs.

Methodology:

This study presents analysis of available research structured around a three-pillar framework:

1. High-Impact Agricultural Innovations – focusing on technologies and practices that address land and water scarcity, improve yields, and reduce post-harvest losses.
2. Innovative Financial Models – including blended finance, digital financial tools, and outcome-linked financing to de-risk investment and align incentives among stakeholders.
3. Enabling Policy and Market Systems – examining regulatory reforms, shock-responsive financing, and public-private partnerships to accelerate adoption and scale.

Through desk research, case studies, and comparative analysis, the paper provides policymakers, investors, and development actors with a practical roadmap for financing resilience in Arab agriculture.

Results:

This paper finds that closing the Arab food gap requires a multi-pronged strategy that integrates high-impact agricultural innovations, tailored financing, and enabling policy frameworks. Controlled Environment Agriculture (CEA), solar-powered greenhouses, and traditional irrigation techniques demonstrate strong potential for resource-efficient food production in arid climates, though scalability remains constrained by capital intensity and regulatory barriers. Financial instruments such as use-of-proceeds bonds, blended finance, and outcomes-linked credit show promise in mobilizing private investment, especially when paired with public guarantees and concessional capital. Policy reforms that reduce collateral requirements, promote strategic reserves, and expand public–private partnerships are essential to build resilient, inclusive, and climate-smart food systems across the Arab region.

Discussion:

High-Impact Agricultural Innovations

i) Agricultural Innovations for Arid Climates

A key solution to addressing food security challenges is to increase domestic agricultural production. Doing so would reduce price volatility driven by transit and foreign exchange costs, as well as decrease the risks associated with exogenous

geopolitical shocks involving exporting countries. However, the Arab world faces unique challenges in promoting domestic agricultural production. Paramount among those challenges is the region's arid climate. Water scarcity, extreme heat, and poor soil quality create barriers to food production endemic to the desert ecosystems of this region.

Over the past several years, technological advancements have unearthed promising solutions to these problems. Many of these solutions were incubated in the Arab region itself, demonstrating their viability in this specific environment. These solutions exist along a spectrum of technical maturity and commercial viability. Some are in nascent stages of development, requiring patient and often concessionary capital, while others have proven track records and are more suitable for institutional-grade or market-rate investors. Chart 1 presents a stylized representation of key agricultural innovations with potential to address Arab food insecurity mapped against these spectra.

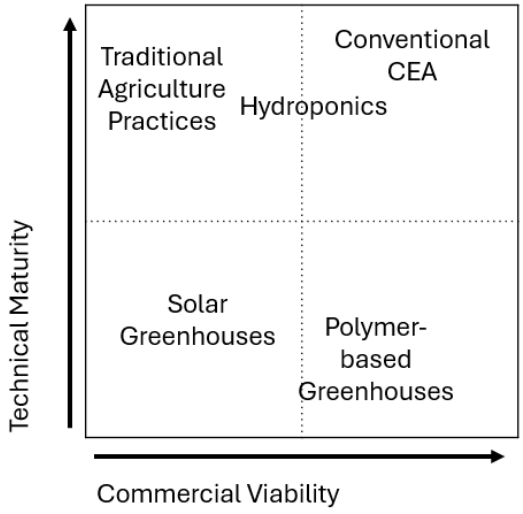


Chart 1: Spectrum of Agricultural Innovations

Source: TCW Research

ii) **Controlled Environment Agriculture (CEA)**

The most mature technologies are those associated with CEA, which refers to the use of enclosed structures such as greenhouses or glasshouses to create optimized growing conditions for plants. These systems allow for precise control over environmental

factors like temperature, humidity, light, and water, enabling cultivation in regions or seasons where traditional agriculture would be impractical or inefficient (Lefers, 2020).

Though CEA systems were originally developed for cold climates, they are showing increased applicability to hot and arid regions. Water conservation is particularly important in the Arab world, where 80% of the region's freshwater resources are used for agriculture. Hydroponic production systems, a subset of CEA in which plants are grown without soil in nutrient-rich water solutions, can reduce water usage by up to 90% relative to field agriculture depending on the system and crop (Regmi, 2024). In hydroponic systems, water use efficiency may be enabled by vertical farming techniques, in which plants are stacked on top of one another so excess water from one plant is used to water plants below it. Likewise, the ability to capture excess water enables a closed-loop system allowing for water reuse.

From an economic perspective, CEA's costs are front-loaded, requiring significant upfront investment outlays. Upfront costs are needed to build facilities and procure the technologies for calibrating the environment. Though, with appropriate operational modifications this agricultural technique not only enables cultivation of various crops, it also provides cost savings over time relative to traditional field agriculture, particularly in inhospitable climates.

At the operational stage, gains in water use efficiency are often counterbalanced by increased electricity and labor costs (Pomoni et al., 2023). Electricity and labor are the two greatest costs associated with CEA, driven by the need for round-the-clock temperature, humidity, and light regulation, as well as the technical skills needed to operate the facility (Wang, 2025). Though investments in CEA have proven to achieve positive NPVs and IRRs, their significant upfront costs and long payback periods are key barriers to scaling these techniques in regions heavily reliant on smallholder farmers.

A World Bank study of climate-smart agriculture (CSA) in Jordan found that investments to transform open-field cultivation of vegetables to hydroponic systems achieved an 11% IRR with a payback period of 10.3 years (World Bank, 2021). In the Jordanian context, initial investment to set up a hydroponic greenhouse with sophisticated sensors and ventilation cost JD 44 per square meter. Though this investment cost is a one-time outlay and enables profitability as soon as the second year

of operation, the initial cost is so high that it requires a decade to recover the initial investment (World Bank, 2021).

iii) Leveraging Desert Ecosystems for Agricultural Innovation

Reframing region-specific challenges, such as high solar irradiation and heat stress, as opportunities to adapt and advance proven agricultural innovations offers solutions unique to the Middle East and North Africa. For CEA to be successful in the desert ecosystem, operators must rely heavily on cooling, ventilation, and artificial lighting. These requirements directly conflict with the regional climate, and their energy intensiveness often increases the greenhouse gas (GHG) emissions associated with CEA relative to traditional agriculture practices.

iv) Solar Greenhouses

More nascent technologies in the renewable energy and materials sciences fields offer promising remedies that leverage the region's consistent and high solar irradiation to provide natural sunlight and energy to CEA facilities. Solar greenhouses, for example, use high-transparency photovoltaic modules mounted on rooftops and windows to capture sunlight for electricity generation while transmitting sufficient light for plant growth (Luo, 2025). These custom-designed panels redirect ultraviolet, violet-blue, and infrared radiation toward PV cells, while maintaining visible light transmission of around 60-70%.

A research-scale solar greenhouse constructed at Murdoch University in Australia using solar panels from ClearVue Technologies piloted this approach. The study found a reduction in energy and water consumption by 57% and 29%, respectively, relative to traditional greenhouses (Luo, 2025). Resource savings were enabled by both energy conservation from reduced reliance on artificial lighting and cooling, and energy generation from the solar panels. Yields for common horticulture crops, such as tomato, beans, lettuce, and bell pepper, were comparable in solar versus conventional rooms. Several crops showed increased productivity, and soil moisture content was higher in the solar greenhouse versus conventional greenhouses (Luo, 2025).

v) Materials Science Solutions

A lower-tech innovation developed by researchers at King Abdullah University of Science and Technology (KAUST) targets similar results with specialized greenhouse cover films

that reduce resource usage while maintaining or improving yields in arid environments. Use of nanoparticle-enhanced covers can reduce heat loads by blocking near-infrared radiation while maintaining photosynthetically active light, enabling passive cooling in arid climates. KAUST-supported field trials found that a combination of cover and ground film reduced soil temperatures by as much as 25.1 degrees Celsius (Tian et al., 2025).

While results show meaningful promise, these technologies are still commercially immature. One company, Iyris, was spun out of the KAUST research effort with backing from investors including the Dubai Future District Fund, Aramco, and Future Investment Initiative. Commercial success of innovative products across a spectrum of technological complexity requires incubation and patient capital.

Greenhouses with transparent solar panels have higher upfront investment costs than traditional CEA facilities, exacerbating economic barriers to scale. Over time, however, studies suggest that solar greenhouses can become 100% self-sustainable and achieve positive ROI (Luo, 2025). Nevertheless, the issues of high upfront costs and long payback periods persist, suggesting that scalability is dependent on significant public or venture investments.

Polymer-based greenhouse enclosures, for their part, require less upfront cost, but have a shorter lifespan than solar modules. Ultimately, farmers must conduct their own cost-benefit analyses to identify the most attractive solutions for their needs.

Traditional Agriculture Solutions

Any discussion of agricultural innovation in the Arab world would be incomplete without consideration of traditional techniques long practiced in the region. Ancient water channeling and irrigation practices like *qanats/aflaj, jessour systems,* and terrace irrigation provide lessons on low-technology sustainable water management (Hassen, 2025). These systems leverage gravity and the natural landscape to channel water from underground aquifers or fluvial or pluvial sources to farmlands. Though these practices are economical, sustainable, and engrained in cultural heritage, they face threats from urbanization, climate change, and policy decisions. Typically, the domain of smallholder and community farmers, these practices also lack the scale required to meaningfully address the region's food security challenges.

Urbanization has led to significant land use change, while climate change continues to alter rainfall patterns. Concurrently, public support for the widespread implementation of modern agricultural techniques, sometimes maladapted to arid ecosystems, has reduced the prominence of traditional practices within Arab agriculture and increased the agricultural sector's energy usage. Over time, generational knowledge of traditional techniques has waned, contributing to agricultural resource overuse, and land and water degradation.

Despite these challenges, beneficial features of traditional techniques can be found in some of the most promising new technologies. For example, gravity-based irrigation systems are reflected in vertical farming practices, which don't require energy-intensive sprinkler systems. Advanced sensing and soil nutrient monitoring, common in CEA, recognize the importance of soil health and moisture levels in maintaining and enhancing yields, while limiting resource depletion. Though industrial-scale agriculture is critical to Arab food security, sustainability tenets of ancient farming practices should be retained as the sector evolves.

Innovative Financial Models

Blended Finance

Mobilizing private capital at scale for climate-aligned agriculture in MENA remains difficult due to structural and policy barriers. Blended finance, strategically combining public and concessional capital to attract private investment, offers a pathway to advance agricultural finance solutions.

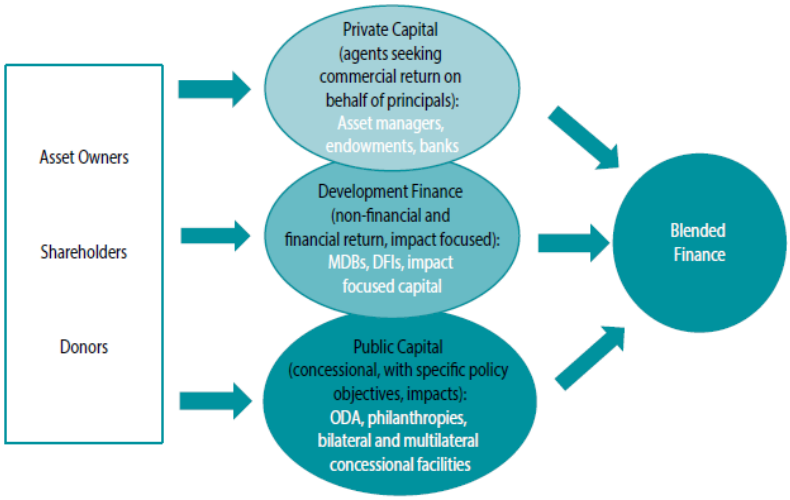


Chart 2: Blended Finance: Structure

Adapted from the Network for Greening the Financial System Technical Document on 'Scaling up Blended Finance for Climate Mitigation and Adaptation in Emerging Market and Developing Economies (EMDEs)', December 2023

To be effective, blended finance requires an integrated ecosystem: lending instruments, risk-sharing mechanisms, standardized frameworks, and project preparation facilities that help de-risk agricultural investments. The Arab region has a foundation upon which to build. Its track record of government collaboration with Development Finance Institutions (DFIs) and Multilateral Development Banks (MDBs) provides effective models of mobilizing capital for agriculture solutions.

Country-Specific Programs

Country-specific blended finance programs offer tailored solutions to unique national government, sectoral, environmental, and market ecosystems. These facilities involve a multilateral institution or provider of concessional capital that works in collaboration with national governments and relevant ministries to harmonize sectoral strategies at a national level. They deploy capital to crowd in private sector investment to fund implementation of these strategies.

The Green Climate Fund (GCF), for instance, was established in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC). It is the largest multilateral climate fund dedicated to helping developing countries reduce greenhouse

gas emissions and adapt to climate change. The facility deploys a variety of financial instruments, including grants, concessional loans, equity investments, guarantees, and outcomes-based investments, to advance its objectives. It partners with national governments through its country platforms to adapt National Decarbonization and National Adaptation Plans into investment pipelines, ensuring that national priorities are centered in capital mobilization efforts.

The GCF's Private Sector Facility (PSF) has catalyzed billions of dollars in private sector investment to advance climate-smart agriculture alongside economic development.

For example, the Jordan Aqaba-Amman Water Desalination and Conveyance Project (AAWDCP) is a large-scale infrastructure project designed to address Jordan's acute water scarcity by desalinating seawater from the Red Sea and transporting it to Amman (Green Climate Fund, 2025). The project involves constructing a solar-powered desalination plant in Aqaba and conveyance infrastructure to transport the treated water over 300 km inland. By improving water security in the country, this project indirectly supports the agriculture sector by developing more extensive and effective water infrastructure with multiple possible end uses. While it is a government-led initiative, the AAWDCP is highly dependent on GCF concessional funding to improve the economics of the project.

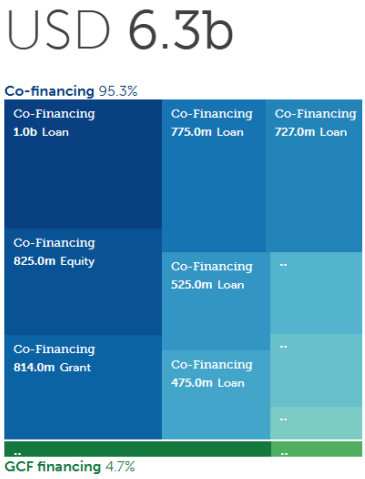


Chart 3: AAWDCP Financing Structure

Source: Green Climate Fund. https://www.greenclimate.fund/project/fp288.

Region-Specific Programs

Regional blended finance programs operate similarly to country-specific programs, but they are also able to leverage the diverse capabilities and resources within the region to support a more resilient multinational ecosystem. In addition, they provide common frameworks and measurement systems to enable more effective cross-boundary collaboration on shared challenges.

The Islamic Organization for Food Security (IOFS) epitomizes this type of regional program. The multinational funding mechanism is designed to mobilize capital for food security across Organization for Islamic Cooperation (OIC) member countries. Like country-specific blended finance facilities, the IOFS leverages concessional capital from MDBs and DFIs and public sector contributions from member countries to catalyze private co-investment. The facility segments member countries by food system maturity to tailor interventions and facilitate targeted knowledge sharing (Islamic Organization for Food Security, 2021).

OIC Member Country Segmentation by Level of Food System Stability

- Group A1 – Established agrifood processors (e.g., Turkey, Indonesia)
- Group B1 – Food secure, import dependent (e.g., Bahrain, Qatar, Saudi Arabia)
- Group A2 – Lagging, high-potential exports (e.g., Afghanistan, Kazakhstan, Niger)
- Group B2 – Least developed, food insecure (e.g., Yemen, Iraq, Somalia)

Green Financing

MDBs/DFIs have played an outsized role in channeling grants, loans, and concessionary capital to climate-resilient agriculture. The World Bank's Roadmap for Climate Action in the Middle East and North Africa plans to mobilize $10 billion in Bank and IFC funding to climate projects and aims to catalyze an additional $2 billion in private capital (Ezzeldin, 2023). Food systems, climate-smart agriculture, water security, and biodiversity are one of four pillars targeted under this plan, which runs from 2021 to 2025. Likewise, the European Bank for Reconstruction and Development (EBRD) and the French Development Agency (AFD) are each active players in the region with dedicated financing facilities for climate resilience and agriculture.

These multilateral and bilateral development banks have pioneered the use of green and 'climate resilience bonds' in the region. As with blended finance structures,

investment-grade issuances with proceeds allocated to emerging and frontier markets can catalyze private investment into sustainability projects that otherwise would have been too risky for participation from institutional investors. Not only do such development-oriented investments mobilize needed green financing, but they are often structured to include technical assistance to local banks, governments, and agriculture firms. Such capacity-building increases the investments' effectiveness in achieving agricultural productivity improvements.

Use-of-proceeds bonds, such as green bonds and novel 'climate resilience bonds', ensure that proceeds raised are allocated to projects with measurable non-financial outcomes. In the sustainable agriculture space, bond proceeds often target yield improvements alongside resource efficiency, training in regenerative farming practices, and ecological conservation efforts. For example, the EBRD issued the world's first climate resilience bond in 2019, with Morocco's Saiss water conservation project as one of its beneficiary projects.

Outcomes-Linked Instruments

Whereas development finance and blended mechanisms channel capital at scale to large agriculture projects, such as industrial vertical farming operations, outcomes-linked financing can be tailored for earlier-stage ventures. These financing mechanisms, well-established in impact investing and formalized more broadly with sustainability-linked loans and bonds, tie financial characteristics, such as interest rates, to contractual outcomes. In the agricultural sector, borrowers are rewarded based on their achievement of targets such as carbon footprint, adoption of cover crops, and soil and water health improvements.

These outcome-linked instruments can be tailored to the specific needs of borrowers based on the maturity of their business and capital requirements. For example, operating loans can include terms to support transition to regenerative agriculture practices, providing both needed bridge financing and technical support to support the adoption of climate-smart agriculture.

Likewise, sustainability-linked insurance products recognize the long-run risks, such as soil degradation and water depletion, related to many conventional agriculture practices. These products help farmers mitigate income volatility while encouraging

adoption of sustainable farming techniques by tying premium pricing or period extensions to eligible counterparties.

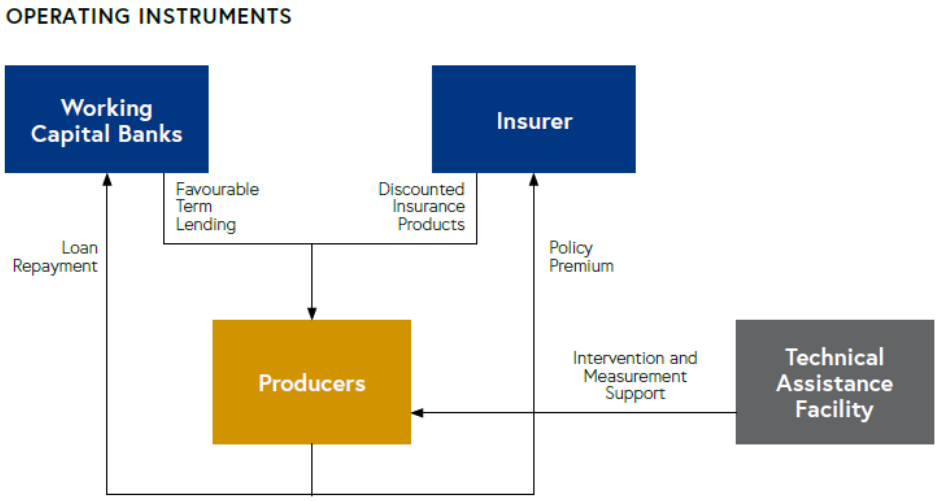


Chart 4: Outcomes-Linked Instruments: Structure

Adapted from Financing for Regenerative Agriculture supported by the Rockefeller Foundation, Transformational Investing in Food Systems, and Pollination. June 2024.

Enabling Policy and Market Systems

Achieving sustainable food security in the Arab region requires more than innovative financing and technological breakthroughs; it depends critically on the policy and market systems that determine whether such innovations can be adopted, scaled, and sustained. Policy frameworks, shock-responsive financing mechanisms, and effective public–private partnerships (PPPs) are essential to reduce systemic vulnerabilities and build resilience. Comparative lessons from Asia's food security crisis responses further highlight the importance of coordinated reserves, supply management, and price stabilization.

Policy Frameworks for Agricultural Resilience

The Arab region's agricultural sector is constrained by fragmented regulatory environments, limited incentives for sustainable practices, and weak institutional

capacity. Regulatory reforms are therefore central to enabling resilience**.** The Arab Monetary Fund and World Bank (2019) note that agricultural lending in the region averages only 7% of total bank lending, compared to 14% in other emerging markets, reflecting high perceived risks and a lack of tailored products. Reforms that reduce collateral requirements, expand the use of non-traditional collateral (e.g., warehouse receipts, crop insurance), and promote branchless banking could ease SME financing and technology adoption.

Incentives for sustainable practices are also critical. Morocco's *Green Morocco Plan* (2008–2020) demonstrated the effectiveness of targeted subsidies for drip irrigation. Empirical studies of Morocco's irrigation transition show that drip irrigation adoption improved farm-level yields and water productivity, although aggregate water savings may be offset by expanded irrigated area (Assouli et al., 2018). Similar incentive structures could be scaled across the region to encourage adoption of climate-smart technologies.

At the regional level, the Arab Strategy for Sustainable Agricultural Development 2020–2030 emphasizes harmonizing agricultural trade and investment policies, rural development, and knowledge sharing (AOAD, 2020). However, implementation remains uneven, underscoring the need for stronger governance and institutional alignment. ESCWA (2019) and FAO stress that secure land tenure, improved storage and logistics, and market-oriented agriculture are prerequisites for resilience. Without such reforms, financial and technological innovations will struggle to achieve scale.

Shock-Responsive Financing Models

The Arab region is highly vulnerable to climate shocks, geopolitical disruptions, and global commodity price volatility. Shock-responsive financing models are therefore essential to provide rapid liquidity and risk-sharing mechanisms. The African Risk Capacity (ARC) has pioneered sovereign insurance pools that disburse funds quickly after droughts, reducing reliance on slow humanitarian aid. Similar regional mechanisms could be developed for Arab states to insure against droughts, floods, or supply chain disruptions.

Emergency credit lines, preapproved by central or development banks, could prevent liquidity crises from cascading into bankruptcies and food shortages. Mobilizing climate finance is equally critical: ESCWA (2025) estimates that $127 billion is needed to address water scarcity alone, yet the Arab region receives only a small fraction of global climate finance. Accessing funds such as the Green Climate Fund and channeling them into agriculture and water management would strengthen resilience. Risk transfer instruments, including weather-indexed insurance and catastrophe bonds, could further diversify risks across global capital markets.

Public–Private Partnerships (PPPs)

PPPs are indispensable for mobilizing capital, sharing risks, and coordinating investments in agriculture. The Arab Authority for Agricultural Investment and Development (AAAID) provides a model, with investments in 45 agricultural companies across 12 Arab countries, generating over 107,000 jobs (AAAID, 2025). By pooling resources from member states and private investors, AAAID demonstrates how PPPs can scale agricultural production and processing.

PPPs have also supported infrastructure development. In Jordan and Egypt, partnerships with international donors and private firms have expanded solar-powered irrigation and cold-chain facilities, reducing post-harvest losses and improving export competitiveness (IWMI, 2024). Moreover, circular economy partnerships in Jordan, Egypt, and Morocco have improved water efficiency and soil health while creating new business opportunities. To maximize impact, PPPs should be structured with clear risk-sharing arrangements, transparent governance, and measurable performance indicators.

Comparative Lessons: Asia's Food Security Crisis Response

The Arab region can draw valuable lessons from Asia's experience in managing food security crises. During the 2008 global food crisis, Asian countries pursued strategies to enhance self-sufficiency while maintaining trade integration. Academic analyses of ASEAN+3's Emergency Rice Reserve (APTERR) identify regional stockpiling mechanisms as an effective institutional tool for crisis response and food security coordination (Kim, 2021). APTERR pooled rice reserves from member states to provide

emergency supplies during crises, stabilizing prices and ensuring availability. Indonesia's recent reforms, including a US$8.6 billion allocation for food security in its 2025 budget, highlight the importance of strategic reserves, diversified staples, and investments in irrigation and logistics (East Asia Forum, 2025).

For Arab economies, adapting these lessons could involve establishing regional grain reserves for wheat and barley, coordinating supply management policies to avoid export bans, investing in logistics networks, and embedding food security strategies into broader development and climate adaptation plans. Such measures would not eliminate import dependence but would reduce vulnerability to external shocks and stabilize domestic markets.

Conclusion and Policy Implications:

The Arab region's food security challenges are deeply rooted in structural vulnerabilities, climate stressors, and financial constraints. While technological innovations offer promising solutions, their success hinges on integrated approaches that combine finance, policy reform, and market development. The path to resilience lies in aligning capital flows with high-impact agricultural technologies, fostering enabling environments, and learning from global best practices. Only through coordinated efforts across public and private sectors can the Arab world reduce its import dependency and build sustainable, shock-resilient food systems. Effective initiatives will integrate the following policy recommendations that focus on strengthening existing resources, establishing new practices, and channeling capital flows to proven solutions.

Phase 1 (0-12 months): Policy alignment and capacity-building for local institutions

a. Embed food security into national development plans: Align agricultural modernization with climate adaptation strategies and broader economic goals.
b. Reform agricultural finance regulations: Remove barriers to financial access by lowering collateral requirements, expanding the use of warehouse receipts, and promoting branchless banking and fintech tools for rural SMEs.

c. Strengthen domestic institutions: Invest in data infrastructure, extension services, and technical training to support precision agriculture and durable adoption of climate-smart practices.

Phase 2 (12-36 months): Pilot blended finance models in priority countries

d. Mobilize climate finance: Tap MDB, DFI, and blended finance structures to attract institutional investments. Leverage mechanisms, such as green and climate resilience bonds, that offer accountability and reporting for sustainability outcomes.
e. Deploy outcomes-linked financing: Tailor financing to business maturity and sustainability objectives by linking financial terms and insurance premia to climate-smart practices and yield improvements.
f. Scale public-private partnerships: Employ PPPs to finance large-scale infrastructure, such as solar-powered irrigation, cold storage, and industrial-scale vertical farms.

Phase 3 (36+ months): Advance regional knowledge-sharing and monitoring frameworks

g. Establish regional monitoring frameworks: Track progress across countries using harmonized metrics and reporting systems to evaluate impact and guide future investment.
h. Preserve and integrate traditional practices: Leverage indigenous techniques like qanats and terrace irrigation to enhance sustainability and embed cultural heritage into modern systems.
i. Facilitate cross-border collaboration: Promote regional grain reserves, supply coordination, and shared logistics to stabilize markets and reduce vulnerability to external shocks.

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تمويل القدرة على الصمود: سدّ الفجوة الغذائية العربية من خلال الابتكار والسياسات

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الملخص:

يتطلب تحقيق الأمن الغذائي المستدام في العالم العربي تعبئة الموارد المالية، وتعزيز الابتكار الزراعي، وبناء هياكل سوقية قادرة على الصمود بما يسهم في الحد من اعتماد المنطقة على الواردات. وعلى الرغم من الدور الذي يؤديه القطاع الزراعي في توفير فرص العمل ودعم سبل العيش في المناطق الريفية، فإنه لا يزال يعاني نقصاً في التمويل، في حين تواجه المؤسسات الصغيرة والمتوسطة، التي تؤدي دوراً محورياً في الإنتاج والتصنيع والتوزيع، عوائق هيكلية تحد من قدرتها على الوصول إلى رأس المال. وتهدف هذه الورقة إلى بيان أن تحديد النماذج التمويلية المبتكرة وتوسيع نطاقها، وتوجيه الاستثمارات نحو التقنيات ذات الأثر المرتفع، وتهيئة السياسات الداعمة، تمثل خطوات مهمة نحو تقليص الفجوة الغذائية العربية وتحقيق تنمية زراعية مستدامة.

وتستند الورقة إلى ثلاث ركائز مترابطة .تتمثل الركيزة الأولى في دراسة الابتكارات ذات الأثر المرتفع التي يمكن تمويلها وتوسيع نطاق تطبيقها في الاقتصادات العربية. وتشمل هذه الابتكارات الاستراتيجيات والتقنيات الرامية إلى التغلب على تحديات ندرة الأراضي والمياه، وإدارة الآفات، وتحسين إنتاجية السلع الزراعية الرئيسة في المنطقة العربية. وتركز الورقة على الحلول التي يمكن من خلالها لتوجيه رأس المال أن يسهم في تعزيز الأمن الغذائي الإقليمي وتحقيق مكاسب اقتصادية أوسع نطاقاً، بدءاً من توفير فرص العمل ووصولاً إلى تحسين الميزان التجاري.

وتتناول الركيزة الثانية استعراض نماذج التمويل المبتكرة القادرة على تحفيز الاستثمارات الزراعية، بما في ذلك التمويل المختلط(Blended Finance) ، والأدوات المالية الرقمية، والتمويل المرتبط بالنتائج (Outcome-Linked Financing)، الذي يربط الخصائص المالية بتحسينات قابلة للقياس في الإنتاج الزراعي. ويمكن لهذه الأدوات أن تسهم في الحد من مخاطر الاستثمار ومواءمة الحوافز بين أصحاب المصلحة الرئيسيين، بما في ذلك مؤسسات الأعمال وصنّاع السياسات والمستثمرون.

أما الركيزة الثالثة، فتتناول تحليل الأنظمة التمكينية التي تشجع على تبني الحلول وتوسيع نطاق تطبيقها. ويشمل ذلك الأطر التنظيمية، ونماذج التمويل المستجيبة للصدمات للتخفيف من آثار الاضطرابات المناخية والجيوسياسية، فضلاً عن الشراكات بين القطاعين العام والخاص التي تتيح حشد الموارد المشتركة مع الحد من التعرض للمخاطر. وتبرز الدروس المستفادة من التجارب المقارنة، مثل إطار الاستجابة لأزمات الأمن

الغذائي في آسيا، كيف يمكن للاحتياطيات الاستراتيجية والإدارة المنسقة للإمدادات أن تسهما في استقرار الأسعار والإمدادات خلال فترات الأزمات.

ومن خلال التكامل بين الابتكار المالي والتحديث الزراعي، **ترسم الورقة** مساراً يمكن لصنّاع السياسات والجهات التمويلية في الدول العربية تبنيه لبناء نظم غذائية قادرة على الصمود، ودعم نمو المؤسسات الصغيرة والمتوسطة، وضمان تحول القطاع الزراعي إلى محرك لتعزيز القدرة الاقتصادية على الصمود على المدى الطويل.

الكلمات المفتاحية : الأمن الغذائي، الابتكار الزراعي، القدرة على الصمود في مواجهة تغير المناخ، إصلاح السياسات، الشراكات بين القطاعين العام والخاص.