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Navigating water scarcity and supporting food security: market-based development of sustainable irrigation

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EXTENDED ABSTRACT

Water scarcity in the Middle East and North Africa (MENA) region is a complex issue influenced by various factors such as climate change, population growth, urbanization, inefficient water management practices, and geopolitical tensions. This situation has significant implications for the irrigation sector in the MENA region, impacting agricultural productivity, food security, and socio-economic development. Some key implications are:

1. **Decreased Agricultural Productivity**. Water scarcity limits the availability of irrigation water for agriculture, leading to decreased crop yields and reduced agricultural productivity. Farmers may struggle to maintain their crops adequately irrigated, resulting in stunted growth, decreased fruit or grain production, and overall lower yields.
2. **Crop Losses and Economic Impact**. Insufficient irrigation water availability can result in crop losses, economic losses, and decreased income for farmers. Crop failures due to water scarcity can have severe consequences for rural livelihoods, exacerbating poverty and food insecurity in affected areas.
3. **Increased Water Stress**. Water scarcity exacerbates water stress in the irrigation sector, as farmers compete for limited water resources to irrigate their crops. This competition can lead to conflicts over water allocation, particularly in regions where water resources are shared among multiple users or countries.
4. **Salinization and Soil Degradation.** Water scarcity can exacerbate soil salinization and degradation in irrigated areas, particularly in arid and semi-arid regions. Limited water availability may result in improper irrigation practices, such as excessive groundwater pumping, leading to the accumulation of salts in the soil and reduced soil fertility.
5. **Shift in Irrigation Practices**. Water scarcity may necessitate a shift towards more water-efficient irrigation practices and technologies, such as drip irrigation, sprinkler irrigation, and precision agriculture. However, the adoption of these technologies may require significant investments in infrastructure and farmer training, which could pose challenges, particularly for small-scale farmers.
6. **Impact on Agricultural Diversity**. Water scarcity can influence the types of crops grown in irrigated areas, as farmers may prioritize crops that require less water or are more drought-resistant. This shift in crop choices can impact agricultural diversity and may have implications for food security and nutrition in the region.
7. **Dependency on Non-renewable Water Sources**. In some cases, water scarcity in the irrigation sector may lead to increased reliance on non-renewable

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water sources, such as fossil groundwater reserves or desalinated water. However, the extraction and use of these non-renewable water sources can have environmental consequences, including groundwater depletion and energy consumption.

Interventions in the irrigation market ecosystem and innovations are crucial for empowering irrigation as an effective adaptation tool in the MENA region. By promoting water-use efficiency, sustainable resource management, resilience to climate change, economic development, environmental sustainability, and adaptation and mitigation, policymakers can help ensure the long-term viability of agriculture in water-stressed environments.

The International Water Management institute (IWMI) and its various partners worked with farmers and other stakeholders in the agricultural water value chain to mainstream inclusive irrigation innovation in the global south, including in MENA.

Case 1: Modernizing irrigation systems in the Nile Delta

In the Nile Delta of Egypt, irrigation systems have historically been crucial for supporting agricultural production in one of the most fertile regions of the country. The Nile River, with its annual inundation, has long served as the lifeblood of Egyptian agriculture, providing water for irrigation and replenishing soil nutrients. Traditional irrigation methods, such as basin irrigation and flood irrigation, have been practiced for centuries, harnessing the natural flow of the river to water crops. In recent decades, modern irrigation infrastructure, including canals, pumps, and water distribution networks, has been developed to enhance water management and increase agricultural productivity. Despite these advancements, challenges such as water scarcity, soil salinity, and the impact of climate change present ongoing concerns for irrigation systems in the Nile Delta, necessitating continued investment in sustainable water management practices and technological innovations to ensure the region's agricultural sustainability.

In 2019, the Government of Egypt started to implement a Nationwide Irrigation Modernization Program, which seeks to convert about 6 million feddans (2.4 million ha) of irrigated land from traditional surface to modern pressurized irrigation systems. Roughly, farm-level investments alone can easily amount to US$3–4.5 billion. These investments are expected to offer significant opportunities for improving the productivity and competitiveness of the agricultural sector. So far, the areas that use modern irrigation systems in Egypt account for 4.6 million feddans. The program is also expected to reduce farm-level water allocations, which could then be reallocated to other sectors including industries, domestic, and the environment. Within this context the International Water Management Institute (IWMI) provided the activity entitled "Egypt-Supporting MALR strategic objective to Modernize the On-Farm Irrigation Systems in Delta (EMFI)" under the Nile Delta Water Management Programme (NDWM), which is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). Under the NDWM, pilots of modern irrigation systems shall be installed in the two demonstration areas to contribute to improving the range of advice and services for smallholder farms on water-saving cultivation practices, initiating innovative measures and digital applications for efficient water use by smallholder farms, and strengthening the participation of civil society and women's groups in water use efficiency.

The project highlighted that solar-powered irrigation systems (SPIS) shall be engineered with multifaceted capabilities, incorporating photovoltaic panels for the capture of solar energy, inverters for the transformation of direct current to alternating current, and grid-tied controllers to facilitate interaction with the public electrical grid (feed in and usage). It also showed that a specialized adaptation shall be undertaken to manage both source water pumps and booster pumps, optimizing flow rates and hydraulic pressure to meet diverse irrigation requirements. To further extend its utility in agricultural settings, the system shall include smart controllers for both irrigation and fertigation, enabling precise, data-driven control over water and nutrient application rates. Accordingly, the business model is featured as a highly customized architecture that not only improves the system's operational efficiency but also offers an integrated solution for sustainable agriculture.

Based on these initial findings, the proposed customization of the market system is shown with all of its elements in Fig. 1.

Case 2: Taking drip irrigation to the next level in Jordan

In Jordan, irrigation systems play a critical role in sustaining agricultural production in a water-scarce environment. The country faces significant challenges due to its limited freshwater resources and increasing water demand. Traditional irrigation methods, such as flood irrigation, have been common historically but are gradually being replaced by more water-efficient technologies like drip and sprinkler irrigation. These modern irrigation systems help optimize water use by delivering water directly to the roots of plants, minimizing evaporation and runoff. Additionally, Jordan has implemented policies to promote sustainable irrigation practices, including water pricing mechanisms and subsidies for water-saving technologies. Despite these

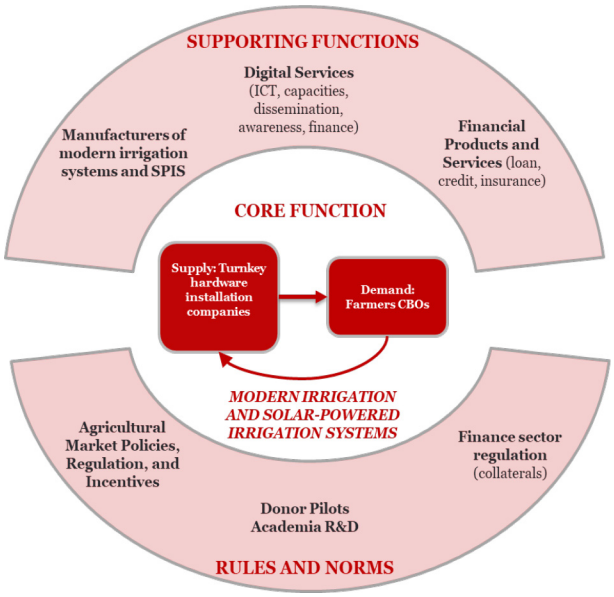

Fig. 1. Modern irrigation systems and solar-powered irrigation systems market diagram of core and supporting functions, and rules and norms that are key for the effective functioning of the market system for water/nutrient. Pesticides saving in agriculture.

efforts, water scarcity remains a pressing issue, and ongoing investments in irrigation infrastructure and management are essential to ensure the resilience and viability of agriculture in Jordan.

Jordan is an exceptional context for policy-makers and development agents to innovate and learn about water management policies and strategies. According to experts, with so few new options for fresh water, the country "will be center stage in showing how a semi-arid region deals with the devastating impacts of a warmer and drier regional climate.

Under the Water Innovation and Technologies (WIT) Program, The goal of the Market System Development (MSD) approach is to contribute to sustainable poverty reduction at scale. This is done through interventions that facilitate sustained changes in the behavior of market actors, and the functions and structures that shape the performance of market systems that matter to people living in poverty.

The WIT program is a five-year initiative implemented between March 2017 and July 2022 in Jordan. It was funded by the United States Agency for International Development (USAID). during the life of the program, the combined efforts of WIT partners, early adopters and farmers led to savings of approximately 24 MCM (in agriculture alone), exceeding the program's target for agriculture by more than 5 MCM. These savings were generated by approximately 200 farmers who optimized around 1,300 ha of farmland (Fig. 2).

To achieve these results, the WIT program explored how water-saving practices and technologies spread, which farmers adopt water-saving technologies and why, as well as technology adoption on farms as well as by different suppliers. Overall, the project identified the water saving market movement.

Overall, market-based development plays a critical role in driving irrigation innovation by enabling the incentivization of investment, promoting efficiency, enabling tailored solutions, facilitating scaling up, and ensuring sustainability. By harnessing market forces, policymakers, businesses, and entrepreneurs can unlock the full potential of irrigation innovation to address water scarcity, enhance agricultural productivity, and contribute to sustainable development.

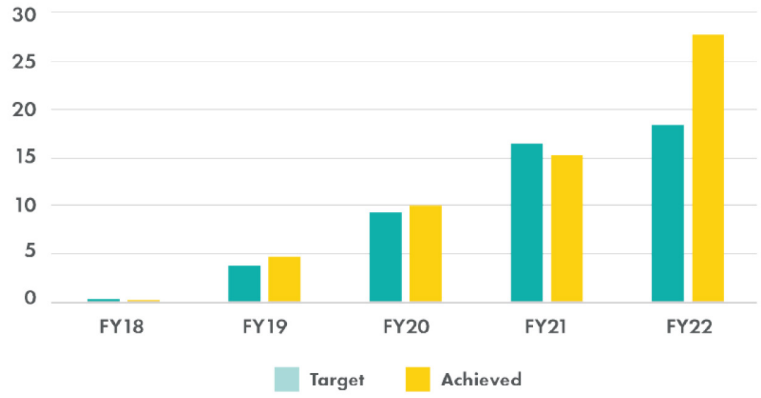

Fig. 2. Accumulated water savings in MCM per fiscal year, including both the agriculture and household components (24 and 4 MCM, respectively).

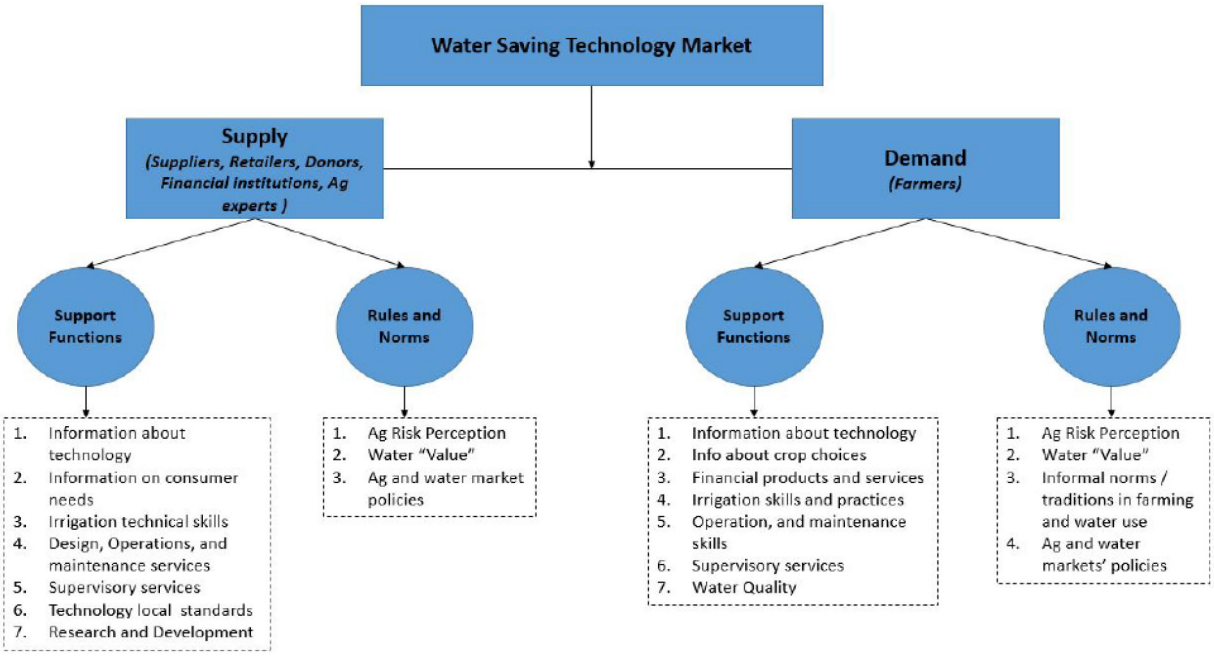

Fig. 3. Water saving technologies market components addressed in WIT.

Keywords: Market-systems; Modern irrigation; Farmer behavior; Irrigation technology