Issue 1
January 2025

SESRI Policy Brief

Adapting to Climate Change for Food Security: Sustainable Agricultural Systems

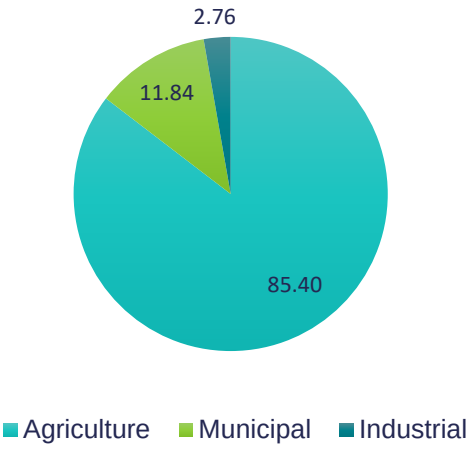
Dr. Sana Abusin, Dr. Adewale Suraj Bello[1], Catalina Petcu, Noor Al-Thani, Alaa Alshareef
[1]Environmental Science Center, Qatar University

Qatar's arid environment, lack of arable land, and limited freshwater resources pose serious threats to food security. As the agricultural sector consumes 85.4% of water, sustainable systems such as aquaculture, aquaponics, and hydroponics are necessary. These alternatives can increase food production, decrease water dependency, and optimize resource efficiency. Aquaculture increases domestic protein sources, aquaponics combines plant and fish farming in closed-loop systems, and hydroponics conserves water while allowing year-round crop cultivation. Despite their potential, these systems face various challenges, including high capital cost, energy demands, and skill deficits. Policy recommendations include financial incentives, capacity building, research funding, regulatory frameworks, and consumer awareness. By implementing these systems, Qatar can become a GCC leader in innovation, minimize its dependence on food imports, maximize its resources, and ensure a sustainable food future.

The State of Qatar encounters noticeable challenges in ensuring food security due to its arid climate nature, limited arable land, and insufficient availability of freshwater resources. Recently, the population has witnessed persistent growth, and despite recent increases in local agricultural production as part of the Qatar National Food Security Strategy[1], the country remains heavily dependent on food imports, including cereals, fruits, legumes, vegetables, and animal products[2,3]. Agriculture is the largest consumer of water in Qatar, accounting for 85.40% of total water use, followed by municipal (11.84%) and industrial (2.76%) uses[4] (see Figure 1).

This reality necessitated a shift toward sustainable agricultural techniques to optimize resource use while enhancing food production without compromising food quality. There are several sustainable systems, but in this review, we will limit ourselves to hydroponics, aquaponics, and aquaculture, as they present promising and sustainable solutions tailored to Qatar's unique environmental characteristics.
This policy brief evaluates the feasibility, suitability, and effectiveness of these systems and proposes a long-term actionable recommendation to support their implementation to enhance sustainable food production in Qatar and other countries with similar climatic conditions.

Figure 1. Water Resource Use by Sector



Challenges to Food Security in Qatar

Traditional agriculture in Qatar is severely hampered by the country's climate and environmental conditions. The nation is heavily dependent on groundwater resources, which are already overexploited, as less than 2% of the land is suitable for farming and the average annual rainfall is less than 100 mm[5]. Furthermore, food

productivity is limited by the salinity of the land and water, rendering traditional farming methods unsustainable. However, Abusin, and Mandikiana (2020) and Bello et al. (2024) reported that traditional agricultural methods could become sustainable with an unconventional irrigation system in place. Innovative and resource-efficient agricultural practices are essential for achieving food security in light of climatic and environmental challenges.

Sustainable Agricultural Techniques for Qatar

1. ***Hydroponics: A Water-Efficient Solution***

Hydroponics, a soilless cultivation method, offers a sustainable solution for a water-scarce environment such as Qatar. By growing plants in a nutrient-rich water medium, hydroponics eliminates dependence on fertile soil and minimizes water use. According to several studies, hydroponic farming techniques can produce more yield without compromising quality while using up to 90% less water than conventional farming techniques[6,7]. This efficient technique is essential in Qatar, where fresh water is a scarce resource. Moreover, the controlled environment of hydroponic systems allows for the year-round production of high-value crops, such as leafy greens, tomatoes, and cucumbers, contributing to a steady food supply[8].

2. ***Aquaponics: Integrating Crop and Fish Production***

Aquaponics is a combination of hydroponics and aquaculture, creating a symbiotic system in which fish waste provides nutrients for plant growth and plants filter and purify the water for fish[9]. Notably, water consumption is significantly minimized by this closed-loop system, which produces both fish and vegetables without compromising quality. Aquaponic techniques have been used effectively in dry and water-scarce places like Qatar[9], indicating that they can simultaneously address resource scarcity and food security. In addition, by promoting eco-friendly methods and reducing dependence on chemical fertilizers, aquaponics supports Qatar's environmental sustainability goals.

3. ***Aquaculture: Expanding Protein Sources***

The supply of fish comes from two main sources: wild-caught fish and farmed fish. Wild fish are caught in natural habitats, such as oceans, rivers, and lakes, while farmed fish are raised in controlled environments through aquaculture. As the amount of fish caught in the wild has stopped growing, more fish will need to be farmed in order to maintain or increase the amount of fish available for each person to eat[10]. Therefore, aquaculture, as a farming system for producing aquatic organisms such as fish, shrimp, and shellfish, offers a complementary approach to leverage the overfishing of wild-caught fish and improving Qatar's food security. As the majority of Qatar's seafood is imported, a growing domestic aquaculture sector can significantly reduce reliance on international markets[11]. The adoption of sustainable aquaculture practices, such as recirculating aquaculture systems (RAS), reduces water consumption and its negative impact on the environment. The sustainability and viability of these systems in Qatar could be further increased by integrating them with renewable energy sources, such as solar energy.

Feasibility and Implementation Challenges

Despite the enormous potential of hydroponics, aquaponics, and aquaculture, there are a number of obstacles to their adoption in Qatar:

1. High initial capital: ***Establishing*** agricultural systems in controlled environments requires a large initial investment in technology, infrastructure, and training. Government incentives and subsidies may be required to encourage

adoption by local farmers with limited capital capacity.

2. Knowledge and expertise: These systems require specific knowledge and skills to operate effectively. Strengthening local capacity by establishing training programs and collaborating with research institutions can increase productivity and reduce long-term dependence on expatriates.

3. High energy demand: Despite their excellent water efficiency, these systems often rely on energy-intensive processes, particularly for water circulation and climate control. Incorporating renewable energy sources such as solar power can address this challenge while reducing greenhouse gas emissions and their long-term environmental impact.

4. Market integration: Establishing well-developed supply chains, gaining market access, and promoting consumer acceptance of locally produced foods are essential to achieving the economic sustainability of these systems. Consumer preferences for locally produced products play a key role in ensuring the long-term success of these systems.

Addressing Qatar's food security challenges requires a paradigm shift toward sustainable agriculture. Hydroponics, aquaponics, and aquaculture offer viable solutions that align with the country's resource constraints and environmental goals. By implementing supportive policies, fostering innovation, and building local capacity, Qatar can reduce its dependence on food imports, conserve precious water resources, and secure a sustainable food future.

References:

1. Bello AS, Huda AKS, Alsafran M, Jayasena V, Jawaid MZ, Chen ZH, et al. (2024). Tomato (Solanum lycopersicum) yield response to drip irrigation and nitrogen application rates in open-field cultivation in arid environments. Elsevier. Retrieved from https://www.sciencedirect.com/science/article/pii/S0304423824004564.

2. Planning and Statistic Authority (2022). Retrieved from: https://wa/en/statistics1/StatisticsSite/Pages.

3. The State of Food Security and Nutrition in the World (2024). Financing to end hunger, food insecurity and malnutrition in all its forms Rome.

4. Ahmad AY, Al-Ghouti MA (2020). Approaches to achieve sustainable use and management of groundwater resources in Qatar: A review. Retrieved from:https://www.sciencedirect.com/science/article/pii/S2352801X19304321.

5. Qatar National Food Security Program (2018). Retrieved from: https://hukoomi.gov.qa/en/articles/national-food-security-program.

6. Bello AS, Ben Hamadou R. Hydroponics: Innovative Option for Growing Crops in Extreme Environments-The Case of the Arabian Peninsula (A Review) (2019). Open Access Journal of Agricultural Research, 4(5).

7. Karanisa T, Amato A, Richer R, Abdul Majid S, Skelhorn C, Sayadi S (2021). Agricultural Production in Qatar's Hot Arid Climate. Sustainability, 13(7):4059.

8. Goh YS, Hum YC, Lee YL, Lai KW, Yap WS, Tee YK (2023). A meta-analysis: Food production and vegetable crop yields of hydroponics. Sci Hortic, 1;321:112339.

9. Rakocy J. E. (2012). Aquaponics—integrating fish and plant culture. Wiley Online. Retrieved from: https://onlinelibrary.wiley.com/doi/pdf/10.1002/9781118250105#page=357.

10. Obirikorang KA, Quagrainie K, Kassah JE and Von Ahnen M (2024) Editorial: Sustainable aquaculture production for improved food security. Front. Sustain. Food Syst. 8:1485956. doi: 10.3389/fsufs.2024.1485956

11. Abusin. S; Washington. B (2020): Towards sustainable food production systems in Qatar: Assessment of the viability of aquaponics. Global Food Security, (25)100348. Retrieved from https://doi.org/10.1016/j.gfs.2020.100349

Policy Recommendations

To promote sustainable agriculture as a strategy for food security in Qatar, the following policy measures are recommended:

1. Financial Support and Incentives:
• Provide subsidies for the setup of hydroponic, aquaponics, and aquaculture systems.
• Create low or zero-interest loan facilities for farmers and entrepreneurs that want to invest in sustainable agriculture technologies.

2. Research and Development (R&D):
• Increase R&D funding to optimize system designs, improve crop varieties, and enhance water-energy nexus and resource use efficiency.
• Collaborate with universities, research institutes, and international organizations to exchange knowledge and best practices.

3. Capacity Building:
• Develop training schemes and frequent workshops to equip farmers, technicians, extension workers, and policymakers with the essential skills required to adopt the implementation and manage sustainable agriculture systems efficiently.

4. Regulatory Frameworks:
• Develop clear procedures, regulations, and standards for sustainable agriculture systems to ensure adequate and environmental compliance.
• Promote public-private partnerships to facilitate the adoption of innovative farming techniques.

5. Public Awareness Campaigns:
• Educate consumers on the benefits of locally produced food to increase demand for sustainable agricultural products.
• Highlight the importance of water conservation and sustainable practices in achieving food security.

6. *Potential Solar Energy:*
• In Qatar, by 2030, the estimated capacity of photovoltaic (utility) energy will be the highest compared to other renewable sources, reaching 2,250 MW.
• Support the ongoing exploration for additional renewable energy sources which will encourage the implementation of sustainable agricultural systems.

7. *Monitoring and Evaluation:*
• Establish a set of sustainability indicators such as carbon footprint and water use efficiency to track the effectiveness of sustainable agriculture policies and technologies.
• Prepare annual reports on the progress of food security and sustainable agriculture goals, which can be used to adjust policies, ensure accountability, and promote transparency**.**