Eliana Jean, PA School for Excellence in the Ag Sciences,
The Baldwin School, Bryn Mawr, PA
Egypt, 2: Water Scarcity

# Aquaponics: The Future of Sustainable Agriculture

Arguably the greatest challenge facing the world today is meeting the nutritional needs of a growing human population projected to hit 10 billion by 2050 (Obirikorang et al., 2021). One country facing the issue of food scarcity due to a growing population and finite water resources is Egypt, an arid land of about 400,000 square miles, located in the northeastern corner of Africa (*Egypt - Land*, 2015). It borders Libya to the west, Sudan to the south, and Israel to the northeast. The most important aspect of Egypt's topography is the Nile River. Throughout its 750-mile stretch, it cuts through barren deserts and provides life to vegetation, animals, and human cities. The Nile enters southern Egypt from Lake Nasir and flows northward toward the capital city of Cairo. In its northern stretch, the river cuts through mountains, and at Cairo, the Nile reaches its delta. From the delta, Egypt is divided into four regions, the Western Desert, the Eastern Desert, and the Sinai Peninsula. The majority of the regions of Egypt, with the exception of the delta, are arid with extremely limited fertility (*Egypt - Land*, 2015).

Egypt's climate is dry and hot with minimal rainfall (*World Bank Climate Change Knowledge Portal*, 2011). It has a mild winter with some scattered rainfall around the coast and a dry summer season. The temperature varies widely in the inland desert areas, especially during the summer, where it ranges from 7°C at night to 43°C during the day. In the winter, the temperature can become as low as 0°C, reaching a high of 18°C during the day (*World Bank Climate Change Knowledge Portal*, 2011). Moreover, the current population of Egypt is 110 million inhabitants with the main ethnic group being Egyptian with Arab ancestry. About 95% of the country's inhabitants live along the banks of the Nile and in the Nile Delta, which flows north of Cairo and along the Suez Canal. The desert and coastal regions, with the exception of Alexandria and a few other cities, are sparsely populated and underdeveloped (*Egypt - People*, 2015).

The average Egyptian family consists of four people with an annual income of 110,000 EGP, equivalent to about 3,600 U.S. dollars. The Ministry of Health and Population governs the health system in Egypt. Though it provides public health services in hospitals and clinics, due to underfunded treatment centers, many Egyptians seek out private health care options (*Egypt | Summary | Columbia Public Health*, 2022). Regarding education, Egypt has one of the most extensive programs, including primary, secondary, and tertiary education, all of which are free (*Egypt Education System*, 2005). For diet, a significant part of Egyptian cuisine is vegetables and legumes, but other meals include meats, most commonly squab, chicken, and lamb (*Egypt - Food*, 2015).

Agriculture is a fundamental component of the Egyptian economy. It contributes to 11.4 percent of the country's GDP and provides up to 23.3 percent of employment (*Egypt Scales up Climate Adaptation Actions of Its Agriculture, Water, and Agrifood Sectors*, 2019). The main agricultural commodities produced in Egypt include rice, wheat, maize, cotton, sugarcane, and horticultural crops such as vegetables, fruit, and dates. However, due to the arid landscape, only 3 percent of Egypt's land is usable for farming. Farms consist of about 2.5 acres on average, and the crops are grown in two seasons

of cultivation, one for winter and another for summer crops. The main summer field crop is cotton which requires large amounts of labor and represents a notable portion of the value of exports. Other important crops include cereals, rice, fiber, and sugar crops. In addition to crops, some farms raise animals such as water buffalo, cattle, asses, goats, and sheep. Animal husbandry and poultry production have been promoted by the government, but the majority of farms raise solely crops (*Egypt Agriculture, Information about Agriculture in Egypt*, 2011).

Since the majority of the population of Egypt lives on a minimal percent of the land, issues have risen over the use of natural resources, specifically the Nile (Farouk, 2022). This crowding has led to pollution while placing a strain on resources, such as clean drinking water. In addition, the majority of the population of Egypt struggles with high unemployment rates. Poverty has also doubled over the last 15 years. Currently, more than 28 percent of the population lives below the poverty line. Other issues with food production include pest damage, climate change, and water scarcity (*Egypt Agriculture Market Analysis - Industry Report - Trends, Size & Share*, 2020). Egypt faces many pest problems, mostly parasitic bacteria that infect crops (*Egypt*, 2007). Since the Nile River is essential for agriculture and drinking water, climate change could impact the flow and flooding of the river.

Water scarcity is one of the most important factors that limits crop production and is responsible for food scarcity in Egypt. Not only in Egypt but also across the Middle East and Africa, freshwater supplies are dwindling. These limited freshwater supplies are needed for many purposes, including farming, household use, and commercial industry (*Egypt - Economy*, 2015). Nearly all of Egypt's freshwater comes from the Nile and its agricultural industry consumes 85 percent of the country's river water (Farouk, 2022). Today, Egypt's available water supply (560 cubic meters per person) has decreased to less than a third of the amount that was available 50 years ago. Thus, the water level available per person in Egypt is significantly below the 1,000 cubic meters per person the United Nations uses to define a country as having water scarcity (Farouk, 2022).

One solution to the issue of water scarcity and its impact on food insecurity is aquaponics. Aquaponics is a sustainable farming method that utilizes a closed system of plants and fish in a tank below to provide nutrients (*What Is Aquaponics? Sustainable, Profitable, Indoor Farming of Fish and Vegetables*, 2017). Plants are situated on a rack without soil and placed into nutrient-rich water. The system works by using the waste by-product from the fish as a fertilizer for the plants. Then, the plants filter and return the water, clean and safe to the fish. In addition to the sustainable system created, aquaponics has many other benefits. Since aquaponics relies on the recycling of nutrient-rich water, there is no toxic run-off as compared to traditional agriculture which pollutes waterways with phosphorus and nitrogen waste. Aquaponics requires no additional source of fertilizer as the fish provide all the nutrients for the plants. The lack of soil needed also eliminates the threat of soil spreading plant diseases. These systems can be implemented in any location, including in indoor greenhouses which allows for the growing of crops year-round. Most importantly, aquaponics uses one-tenth of the water of traditional agriculture and produces 8 times more food per acre (*The Aquaponic Source*, 2019). Many systems also utilize Nile Tilapia to provide nutrients, and the fish are then raised, sold, and used for food consumption. Especially in an arid climate, like Egypt, aquaponics could dramatically increase the food supply, conserve water, and reduce the environmental pollution of the Nile.

Aquaponics is easily able to be implemented in both rural and urban environments. Aquaponics systems can range in size from local systems in urban buildings to full-scale crop production for farms. In small-scale systems, which can be implemented within city buildings and personal homes, aquaponics can serve as a replacement for backyard gardening in areas with limited space. In terms of area, per square foot, aquaponics is the most productive form of agriculture and is a perfect example of a self-sufficient system that functions like an ecosystem, producing food without creating waste products or pollution. The only materials needed are a tank, grow bed, aerator, and fish to supply nutrients (*The Aquaponic Source*, 2019). This system can then provide a sustainable source of vegetables, a resource any urban-based family would appreciate. In more rural areas, commercial aquaponics systems can be implemented on small and large scales. Large-scale commercial aquaponics systems use up to 5,880 square feet and produce about 80,000 – 110,000 plants per year. In addition, these aquaponics systems can produce 6,000 pounds of whole tilapia per year (Nelson and Pade, 2021). Both large-scale systems and personal aquaponics gardens are sustainable methods to produce nutritious crops and combat water scarcity.

There have already been pilot programs in other countries which repurpose traditional farms into aquaponics systems. In Hilliard, Florida, the Traders Hill Farm aquaponics system was created in 2013 as an experiment but now is a flourishing income segment. This aquaponics farm repurposed a 400-by-37-foot chicken barn to create its aquaponics system, which is now producing 1,000 lbs. of fish and 4,000 lbs. of lettuce every month. More importantly, Traders Hill Farm was able to provide the region with sustainable, clean, and wholesome produce (*Agritecture*, 2022). This idea of repurposing traditional agricultural systems to aquaponics farms can be applied not only to systems in the United States but also in Egypt as water scarcity encourages the transition away from traditional agriculture and towards aquaponics.

Already in Egypt, attention is being turned toward sustainable farming methods. In 2015, only one commercial aquaponics farm was operating in all of Egypt, despite the water-saving benefits (Obirikorang et al., 2021). Currently, a few more aquaponics companies have opened, but they still consist of a significant minority of the agriculture industry. Aquaponics farms are easily scalable and able to be adapted to the average small farmer's land plot, while also allowing for previously infertile land to become the grounds for new systems. The key to lowering aquaponics costs is to develop a standard, user-friendly technology, i.e. water pumps, fish holding tanks, hydroponic containers, etc that are applicable to all local farmers. Through governmental support and large scaling of the industry, the costs of aquaponics systems could be dramatically reduced. Despite higher initial capital and operating costs, aquaponics is more profitable and saves 90 percent of the water that traditional farming utilizes (*The Aquaponic Source*, 2019). Another limitation to the creation of widespread aquaponics systems in Egypt is the lack of training to aid farmers in the adoption of these sustainable systems. To combat the initial cost of aquaponics, the Agricultural Bank of Egypt coupled with the Ministry of Agriculture could provide funding via the 25 million dollar Egyptian Climate Resilience venture capital fund (Hennawy & ZAWYA, 2022). This fund was created in November of 2022 to combat the misuse of agricultural land in the Middle East and Egypt. In order to educate farmers on how to use these new systems, training and informational courses would be provided. The fund is not limited to homegrown startups; it targets agriculture entrepreneurs from every corner of the world provided they are willing to operate in the Middle East and Africa. In addition to the climate resilience fund, government credit for water costs, or long-term, interest-free loans could be given to start-up aquaponics farmers.

As the population of Egypt and the world is on the rise, the issue of food security becomes more pressing and important. Egypt's dry and inhospitable land limits the available fertile area for agriculture to only three percent of the land. The Nile River provides a source of fresh water but faces pollution from agricultural runoff. Aquaponics is one of the solutions to Egypt's water scarcity issues. By implementing this sustainable farming technique, not only will water be saved but also crop yield will increase. The 27th UN Summit on Climate Change brought the attention of the world to sustainable agriculture, thus inspiring and aiding change that will benefit the lives of millions.

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