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Egypt, Sustainable Agriculture
Egypt's Future Through Sustainable Agriculture: Why and How

The largest threat to Egypt's current food security is their lack of agricultural sustainability. With a population of almost 95 million, an incredibly limited water supply, and an available arable land area of only 7.2 million feddans, about 3 million hectares, the country of Egypt currently faces uncertainty in its future food security (EI-Sherif, 1997). (The traditional unit of land measurement in Egypt is the feddan, where 1 feddan = 0.42 hectares.) Due to its arid climate, present farmland in Egypt is irrigation based; this limits farming to the 3% of Egypt's land area that is either along the Nile river or surrounding the country's few scattered oases. These factors have put considerable stress on Egypt's primary water source, the Nile River, making the current agriculture systems in the country unsustainable especially considering the country's growing population. With irrigation-based agriculture, a high-density population, and pollution from pesticide use all putting a strain on Egypt's limited water supply in addition to their current pest problems and potential soil depletion, Egypt may soon be facing severe food security issues unless sustainable agricultural practices are applied to their current agriculture system.

The average family in Egypt has "4.2 people per household" ("Average Household Size in Egypt," 2018), and almost 70% of the population lives in apartments (Chernyshev, 2015). 57% of the country is rural and 43% is urban, with the majority of the population clustered along the Nile River ("Egypt Urban Population", 2018). While the average family in Egypt eats a mostly vegetarian diet that includes lots of legumes, these families will occasionally have lamb, poultry, or fish for meat, cooked most commonly in a kebab style (Wise, 2017). Bread is the primary staple in Egypt, and other food can be purchased at large markets that consist of many small sellers rather than large commercial distributors (Hopkins and Saad, 2018) The minimum monthly wage is 1200 Egyptian Pounds, about $67 ("Egypt Minimum Monthly Wage", 2018). "One in every three workers in Egypt are farmers", and the other main industries are tourism, pharmaceutical companies, and computer companies ("Living in Egypt Jobs", 2014). The Egyptian government offers universal healthcare to its citizens with "basic medical services" available in almost all villages (Hopkins and Saad, 2018); likewise, public education is offered from kindergarten to preparatory school (Rose, 1995). Almost all people in Egypt have access to water, electricity, toilets, cellphones, paved roads, and markets, but the country has a large economical divide between the upper-class and the middle and lower classes. The main crops produced in Egypt are rice, cotton, sugarcane, food legumes (broad beans and soy beans), citrus fruits, and vegetables (tomatoes and potatoes) (EI-Sherif, 1997). Farms in Egypt are on average 2.5 feddans, about the size of a rugby field (EI-Sherif, 1997), and the country's agriculture system is comprised of numerous small farms rather than large commercial farms ("Agriculture and Food Security," 2017).

The first method that may help to ease the current strain on Egypt's limited water sources and increase agricultural area is the implementation of hydroponic and aquaponic systems (Dakkak, 2017). Hydroponics is a method of growing plants without soil, and it has been around for the past 40 years. In a hydroponic system, the plant develops in a soilless growing medium such as gravel or coconut fiber, and a nutrient solution is pumped through the medium which nourishes the plant. Recently a new form of hydroponics has been developed called aquaponics. An aquaponic system combines aquaculture (fish farming) and hydroponics so that the waste created by the fish provides the nutrients for the plants. Unlike hydroponics, aquaponic systems do not require the input of chemical nutrients and provide two products that can be sold for profit: fish, which are one of the few meat sources in Egypt, and vegetables/cereals. Both hydroponic and aquaponic systems are practical parts of sustainable agriculture because both use "less water as compared to traditional farming" (Ernst and Busby, 2009) and therefore make agriculture less reliant on "the use of ground water for irrigation" (Childress, 2002). Moreover, these systems are substantially more space efficient than common agriculture, and because these systems do not require soil, they can be constructed and operated in the desert, expanding agriculture to currently nonarable land in Egypt. Some systems have been developed that are fairly inexpensive to manufacture and maintain, able to grow a "wide variety of plants like tomatoes and beans" that can serve as a food source, and sufficiently compact to be used by those who live in congested slums like those on the outskirts of Rio de Janiero (Lloyd, 2005). Similar systems currently being introduced in Cairo will be able to "increase the availability of natural and safe food to the poorest classes of the population" including beans that make up a fair portion of an average Egyptian family's diet (Giro, Ciappellano, and Ferrante, 2016). Hydroponic and aquaponic systems that are in greenhouses also allow the grower to keep the growing spaces "under carefully controlled conditions" (DeKorne, 1992); this extra control allows hydroponic systems to repeatedly produce "double crop yield over that of regular soil" ("Hydroponics", 2004). For example, the "yield of tomatoes in soil is from five to ten tons per acre" which is a small amount when compared to the "between sixty and three hundred tons per acre" that is achievable through a hydroponic system (DeKorne, 1992). While the hydroponic system still possesses the drawback of requiring fertilizer solutions that are typically based on petro-chemicals, it is still able to out-perform conventional modern agriculture time and time again. Furthermore, the use of these chemicals is not required in aquaponic systems. While startup costs of these systems are high, increasing production and requiring minimal manual labor for operation makes the use of hydroponic and aquaponic growing systems economically viable in the long run. On the whole, hydroponic and aquaponic systems are potential techniques that can be incorporated into Egyptian agriculture to make it more sustainable because of their ability to conserve water, be space efficient, be cost effective, expand the current amount of farmland, and consistently surpass the production potential of conventional agriculture.

Secondly, one of the more damaging aspects of Egyptian agriculture is the severe use of pesticides and nematicides. The most difficult obstacle that farmers in Egypt currently face is "damage caused by pests", and the most common pests encountered are nematodes (EI-Sherif, 1997). Currently farmers have only nematicides to combat this issue, but because of government price regulation on certain crops, this process is only economically viable for small greenhouse farms (EI-Sherif, 1997). Pesticides, herbicides, nematicides, and many other "cides" are used regularly in agriculture. These toxins build up in the soil, which negatively affects "beneficial insect species, soil microorganisms, and worms responsible for soil health" (Holmes, Mandjiny, and Upadhyay, 2016). Moreover, as pesticide, nematicide, and herbicide use continues, the organisms they target develop resistance, which requires pesticide manufacturers to create new and often more dangerous pesticides. For these reasons and many others, if agriculture is to be sustainable, then alternative methods to the use of pesticides must be developed and implemented.

As discussed previously, the use of hydroponic systems may be an effective means to reduce if not eliminate the need for pesticides. In California, strawberries are being grown in hydroponic systems that require no application of pesticides; this is especially surprising because strawberry cultivation in the past has relied heavily on the use of dangerous pesticides such as methyl bromide that is used to fumigate the soil and kill "soil-borne insect pests" (Stanley, 1998). As a result of the controlled conditions offered by an enclosed hydroponic system, growers are able to effectively control pests with "beneficial predatory mites" and prevent fungal diseases by "moderating the humidity level in the greenhouse and by growing varieties that resist mildew infection" (Stanley, 1998). Also, nematodes and other soil borne pests cannot survive and reproduce in the soilless environment present in hydroponic and aquaponic systems.

In addition to hydroponics, biological control can be used in soil agriculture to reduce the need for pesticide use. The use of biological controls is no recent discovery; this practice involves introducing natural predators such as "parasitoids, predators, microbes, and beneficial nematodes" that reduce pest populations (Holmes, Mandjiny, and Upadhyay, 2016). This method of control has "been employed for decades with no documented adverse effects"; additionally, the use of biological control has "a high benefit to cost ratio", does not share the negative environmental and health aspects of chemical pesticides, creates “no resistance buildup” in insects, protects biodiversity, and aids in “restoring natural ecosystems” (Holmes, Mandjiny, and Upadhyay, 2016). Also, biological controls may offer a more economic form of pest control for Egyptian farmers, since biological control methods my not be required to be applied as frequently as expensive chemical pesticides. Because of these numerous advantages, the use of biological controls is clearly superior to pesticides and would be a necessary component of sustainable agriculture in Egypt.

A newer but equally promising approach to “reduce the need for pesticides and herbicides” is the cultivating of genetically modified crops (Kaplan and Winklerprins, 2017). The most common herbicide resistant crop is resistant to glyphosate, commonly known as Roundup, and this resistance allows farmers to spray their crops indiscriminately while only killing unwanted weeds. While this may not immediately seem to be environmentally friendly, the use of glyphosate is preferable to that of other herbicides such as metolachor because glyphosate has a “very low acute toxicity” and “breaks down quickly in the environment”; therefore, these herbicide resistant crops help reduce the use of even more harmful herbicides that can build up in the soil or pollute water sources and thereby help “foster use of low-till and no-till agriculture” (Ronald and Adamchak, 2008). The development of Bt (*Bacillus thurgienis*) toxin crops has been able to fully eliminate the need for pesticides. These crops have had their DNA altered so that they produce the Bt toxin; as a result, when a pest such as a corn earworm eats any part of the plant, it is poisoned without the use of applied external pesticides (Ronald and Adamchak, 2008). Such varieties are additionally advantageous because the toxin produced by the plant causes “little or no harm to most non-target organisms including beneficial insects, wildlife, and people” (Ronald and Adamchak, 2008). A common problem created by chemical pesticide use is the development of resistance to the pesticide by target insects. The use of the “refuge strategy” has prevented insects from developing resistance to the Bt toxin in these genetically modified crops (Ronald and Adamchak, 2008). Lastly, genetically modified crops can be designed to be “resistant to common plant diseases” that can cause significant crop loss (Freedman, 2003). In conclusion, incorporating hydroponics, biological controls, and genetically modified crops can make conventional agriculture in Egypt more sustainable and more environmentally and economically friendly by reducing the need for pesticide use.

The final and possibly most important way to make agriculture in Egypt sustainable is promoting the practice of soil care and maintenance. Any home gardener will know that “good soil is the foundation of a successful vegetable garden”; however, this basic principle has been forgotten in commercial agriculture (Fell, 1982). Egypt already has a limited amount of arable land, and extreme precaution should be taken to preserve what is regarded to be some of the most fertile soil in the entire world. Intensive use of chemical fertilizers combined with continuous cultivation and tillage has left a large portion of the world’s farmlands severely depleted and caused the “consequent destabilization of soil structure” (Crocker et al., 2000). Moreover, continuous input of chemical fertilizers paired with the economic and environmental cost of operating large tillage machines has made modern agriculture economically unsustainable. Nevertheless, techniques such as indigenous soil care, crop rotation, and no-till farming are beginning to be reincorporated into agriculture because of their ability to improve soil quality and thereby reduce the input costs of farming.

Indigenous soil care practices have been developed over hundreds of years and may play a role in “fostering sustainable agriculture development” (Rajasekaran and Warren, 1995). Many of these practices involve the application of manure, crop rotation, and the growing of legumes to improve soil nutrients. Research into these methods has “now demonstrated the cost-effectiveness of indigenous soil and water conservation practices” (Rajasekaran and Warren, 1995). The application of manure has been shown to “replenish soil organic matter” and improve “the structure of the soil”; furthermore, the addition of manure “prevents soil erosion to a significant extent” (Rajasekaran and Warren, 1995).

In addition to indigenous practices, recent research into both the use of cover crops and no-till farming has proven these methods to be effective in improving soil health. Growing cover crops in-between the cultivation of high input crops such as corn has been shown to cause “improvement in soil structure” (Crocker et al., 2000), increase “soil water infiltration and storage capacity” (Schmidt et al., 2018), “reduce erosion” (Schmidt et al., 2018), and present numerous other benefits. The benefit of reducing water use by improving soil structure is especially important for an arid country like Egypt with a limited water supply. A study on the effects that the use of crop rotation and cover crops has on corn yields revealed that “corn yield following wheat was…at least 31% higher than both entry points of corn following corn” resulting in the conclusion that cover crops and crop rotation are essential in systems “designed for high productivity and lower input potential” by “reducing fertilizer input” (Jones et al., 1998). Further, “diversified crop rotations reduced external N inputs,” thereby making farming more economically sustainable by reducing “the cost of N fertilization” (Sainju et al., 2018). Lastly the adoption of no-till farming techniques has shown to have many of the same beneficial effects as the use of cover crops, especially helping to improve “water holding capacity and reduce erosion” (Schmidt et al., 2018). No-tillage farming creates a more diverse microbial community in the soil compared to tillage farming indicating better soil health (Schmidt et al., 2018). In brief, an essential element of sustainable agriculture is the use of “improved soil care and nutrient management” (Yaalon, 2000) through the use of techniques such as indigenous soil care practices, crop rotation, cover crops, and no-till farming. These techniques will both help protect and improve the limited farmland in Egypt and reduce the water inputs required in modern agriculture.

To conclude, modern agriculture as we know it today is woefully unsustainable, inefficient, and expensive, especially for small Egyptian farms. Many methods that farmers presently use to produce more crops are not only environmentally harmful but also economically impractical. In order for Egypt to steer away from this path that will ultimately lead to the widespread depletion of its farmland and loss of the country’s food security, changes will need to be made. Science has shown and proven that hydroponic systems, biological controls, genetically modified crops, indigenous soil care techniques, crop rotation, cover crops, and no-till farming can all work to increase farming efficiency, reduce chemical pesticide and fertilizer use, improve soil health, and reform Egypt’s agriculture to be more economically and environmentally sustainable. For this to happen, the World Bank or other global aid agencies should work in tandem with the Egyptian government to educate farmers on these new practices and encourage policies that limit the current farming methods that threaten Egypt’s farmland and water sources. The Egyptian government will have to help fund the establishment of hydroponic and aquaponic greenhouses and ensure that those in charge of these facilities are able to adequately operate them. The current agricultural practices in Egypt will not be able to continue to provide for its growing population. The new approaches as discussed above can all help to reduce the heavy toll that agriculture currently takes on Egypt’s environment, economy, and society as a whole and lead the country into a brighter, more sustainable, future.

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