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Pursuing Sustainable Agriculture in the Bahamas

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ABSTRACT

There is currently a distinct lack of domestic agricultural production in the Bahamas. As a result, food imports cost the country nearly $1 billion annually, causing both economic stress and food scarcity in some areas. The land in the Bahamas does not have characteristics suited to industrialized agriculture, but modern sustainable technologies could be viable agricultural options for Bahamians to pursue. These include hydroponics, aquaponics, and permaculture. Hydroponics and aquaponics use similar soilless technologies to produce food while permaculture is a land-based agricultural method that focuses on imitating natural ecosystems. While each of these methods have benefits and drawbacks, aquaponics seems to be the most promising method for the Bahamas because it can be used anywhere, regardless of soil quality or availability and provides the opportunity to produce both a protein food source in the form of fish and a vegetable or fruit food source. Producing sustainable food domestically through the use of aquaponics technology can boost the Bahamian economy by reducing agricultural imports and creating job opportunities in the agricultural sector.

INTRODUCTION

Currently, the agricultural sector in the Bahamas is nearly non-existent, comprising only 2.1% of the country's gross domestic product (GDP) in 2014 (Central Intelligence Agency 2016). The country imports nearly $1 billion of food annually, contributing to their hefty trade deficit of $3.1 billion (Wells 2015 and Hartnell 2015). In addition to economic stress, the lack of agricultural production within the Bahamas causes food scarcity for the populace, especially those residing on the out islands (Smith 2013). While the land in the Bahamas is not particularly amenable to mass-production agricultural practices, implementing newer technologies may reduce the Bahamas' reliance on foreign food sources, resulting in a smaller trade deficit, a more diversified economy, and increased food security.

As sustainability becomes an increasingly important goal worldwide due to the overwhelming effects of climate change, the Bahamas should strive for greater agricultural independence while pursuing food production methods that will not cause environmental damage. Technologies such as hydroponics, aquaponics, and permaculture are all potential options that could be adopted in the Bahamas. This paper will examine the current state of agriculture in the Bahamas and important factors to consider when determining possible agricultural methods for the future as well as reviewing those methods and concluding with recommendations for a course of action.

AGRICULTURE IN THE BAHAMAS

The majority of modern-day Bahamian farms are used only for subsistence, though there are a small number of commercial farms, mostly run by expatriates on the northern islands (Hedden 2011). While a few of these farms have found success in agritourism ventures, this economic opportunity

seems to have eluded most native Bahamian farmers (Hepburn 2010).

Historically, agriculture has not been particularly successful in the Bahamas. The oldest method, "pothole farming," still used in some areas, was invented by the Lucayans, the original inhabitants of the Bahamas (Sealey 2010). Pothole farming consists of burning the wild bush so that the underlying limestone karst formations are exposed. Soil, along with the carbon-rich ash created by the burning, accumulates in the holes in the exposed bedrock, providing small "potholes" that can be used for planting. The main issue with this method of farming is that the "potholes" become so degraded within one year that the bush must grow back, taking 15 to 25 years, before the process can be successfully repeated (Sealey 2010).

Figure 1. Pothole farming in the Bahamas (Climate Change Initiative 2014).

Prior to emancipation in the Bahamas, there was also a plantation system in place similar to that of other Caribbean islands and the American South. However, by 1800, the cotton-based plantation system in the Bahamas had already collapsed at least partly due to the "exhausted state of the soil" (Johnson 1988). As a result, many slaves were sold to other Caribbean colonies and those remaining often lived in especially miserable conditions because their owners were poor due to the lack of profit in agricultural activities.

Pineapple cultivation developed around 1832, especially on the island of Eleuthera (Johnson 1988). While this trade was initially profitable due to a newly emerged market for tropical products in North Atlantic countries, it petered out early in the 20th century due to duties and tariffs instated by the United States at the encouragement of Florida pineapple growers (Bartholomew et al. 2012).

A large part of the reason why mass agriculture is not a major contributor to the Bahamian economy is due to the characteristics of the land that prevent large profit margins. This in turn has deterred many native people from pursuing agricultural work; agricultural workers made up only 4% of the Bahamian workforce in 2011 and the majority of that 4% was migrants from Haiti (Smith 2013).

FACTORS TO CONSIDER

In the effort to establish greater domestic agricultural production in the Bahamas, there are many important factors to consider. These include the capacity of the other land to support crop growth, based on its geology and soil characteristics. The availability of arable land is also an essential figure to examine. Intensive reviews of agricultural methods need to be completed in order to determine the feasibility of each method as well as their potential for widespread adoption and growth. A method should only be chosen if its output will be greater than its initial costs within a reasonable amount of time. A final consideration is the availability of labor within the country and whether any specialized skills would be necessary for workers to learn for each method. The following sections will examine these factors in greater detail.

THE LAND OF THE BAHAMAS

As previously mentioned, the land of the Bahamas is not ideal for agriculture. This is because the islands are made of primarily limestone, which is formed in shallow marine environments from the calcite shells and skeletons of marine animals. Limestone dissolves when it comes in to contact with rainwater so unlike other types of bedrock, its material does not form soil as it weathers (Sealey 2010). In consequence, most soils in the Bahamas are considered to be "protosols," a term used to refer to poorly developed soils, making them not ideal for agricultural use. These protosols are all alkaline, having a pH ranging from 7.5 to 8.5, which can limit the ability of growing plants to absorb water. Along with the native soils, there is wind-blown dust from the Sahara that appears red due to the presence of iron oxides. The red soil does not have much nutrient value, but has more depth than

soils on the islands and can be used with the addition of fertilizers (Sealey 2010).

Figure 2. Red soil on Eleuthera in the Bahamas.

The Bahamas also has a limited amount of land available for agriculture, though the exact amount seems to be in contention. According to the Bahamian government, there are 245, 737 acres of arable land in the Bahamas, equivalent to 7% of the total land area (Government of the Bahamas 2011). However, according to the Central Intelligence Agency's World Factbook, the total agricultural land in the Bahamas accounts for only 1.4% of the total land area (2016). The Bahamian government may be including land that is currently being used for other purposes or may be overly optimistic regarding the country's agricultural opportunities. In any case, the Bahamas has a limited amount of land available in general due to being an archipelago and the previously mentioned geologic conditions further restricts the amount of land suitable for agricultural production.

POTENTIAL SOLUTIONS

There are a few modern methods of food production championed by the sustainability movement that may provide options for future development of agriculture in the Bahamas. These include hydroponics, aquaponics, and permaculture.

DISCUSSION OF HYDROPONICS

Hydroponics is the method used to grow plants in a soilless system (Love et al. 2014). The type of hydroponic system can vary. There are Ebb and Flow systems, Nutrient Film Technique (NFT), Aeroponic, Water Culture, Wick, and Drip. All of these designs share the same basic characteristics: a water supply, a nutrient solution, and an absence of soil (Ernst and Busby 2009).

The Nutrient Film Technique was first used in the 1960s and is still widely used amongst hydroponic growers due to its relatively inexpensive and simple setup (Ernst and Busby 2009). In an NFT system, plants are provided a shallow flow of nutrient-rich water, creating a "film" over their roots.

Figure 3. Nutrient Film Technique (Hydroponics World 2016).

Another common hydroponics setup is Water Culture, also sometimes referred to as floating rafts. The plants are potted and placed in "rafts" of a material that will float on water. In this system, an air pump is used to aerate the nutrient solution that the plants float on, providing oxygen to their roots (Ernst and Busby 2009).

The drip hydroponic system is very popular because it uses only the exact amount of solution needed. A pump controlled by a timer is hooked up to a drip line that will provide the nutrient-rich solution to the plants, which can then be filtered through the plant's growing medium into a reservoir (Ernst and Busby 2009).

Instead of soil, a variety of growing media can be used both to support seed germination and provide nutrients to plants growing hydroponically (Rapaka 2013). It is important for the growing media to have the ability to retain water, but allow aeration for the plant's roots. Some common types of growing media are coconut coir, produced from coconut husks, vermiculite and perlite, produced from rocks and minerals, and peat-based media. Some hydroponics growers

may also choose not to use a growing media, leaving the plants' roots bare (Jensen 2013).

Figure 4. Types of Growing Media (EPGMA 2015).

Hydroponics systems can be considered either "open" or "closed." In an open system, the water used to bring nutrients to the plants is not reused in contrast to being recaptured, replenished, and reused in a closed system (Jensen 2013).

Hydroponics systems range in size from large commercial operations to small home setups. Their use has become more and more popular because they are considered to be sustainable as well as easy to setup and maintain.

The major benefits of hydroponics systems are that they can be set up almost anywhere and do not require any soil for plants to grow. Hydroponics systems, especially those of the drip variety, also use far less water than traditional agricultural methods (Ernst and Busby 2009).

The potential obstacles to hydroponics use include the initial investment to set up the system as well as the need for reliable electricity to run the pumps in recirculating systems.

DISCUSSION OF AQUAPONICS

Aquaponics is a type of food production system that integrates aquaculture and hydroponics (Love et al. 2014). An aquaponics system allows water from aquaculture tanks, including nutrients from fish waste, to flow to plants growing hydroponically. The plants can then utilize the nutrients from the water, cleaning it in the process. Finally, the clean water is diverted back to the aquaculture tanks (Love et al 2014).

Experimentation with aquaponics first began in the 1970s, shortly after researchers developed Recirculating Aquaculture Systems, an essential technology allowing water to cycle in an aquaculture system (Love et al. 2014).

In aquaponic systems, the plant species that are primarily grown are leafy greens such as lettuce, herbs such as mint, and tomatoes (Love et al. 2014). The most frequent types of fish used are tilapia, catfish, or ornamental fish. Tilapia is the preferred type of fish used because of its ability to survive in poor water quality and at high densities. One negative aspect of using tilapia is that their widespread use has prevented other fish species from being researched as possibilities for aquaponics. Tilapia is also an invasive species in some parts of the world and if released from an aquaponics system into a natural environment could cause problems in local ecosystems (Love et al. 2014).

There are a variety of setups for the plant beds in aquaponics systems, similar to those of hydroponics systems. These include media beds, water culture (floating rafts), nutrient film technique, vertical towers, wicking beds, and Dutch buckets. Operators of aquaponics systems can choose the setup that best fits their available space, as well as the plants that they intend to grow. Leafy greens can do well in all of the setups, while tomatoes may thrive using a vertical setup (Love et al. 2014).

Figure 5. Floating raft aquaponics system at Cape Eleuthera Institute.

When compared to traditional agriculture, aquaponics can provide a variety of benefits to the consumer, the producer, and the surrounding

environment. These include using significantly less resources as well as avoiding inputs from pesticides and fertilizers. Because aquaponics are closed systems, they do not contaminate the surrounding environment with any sort of pollutant or runoff. Aquaponics systems can produce 150-200% more food per square foot as opposed to traditional planting. Aquaponics also requires 5-10% of the amount of water needed for traditional agriculture. Aquaponics systems can also be used to produce food on non-arable land (Somerville et al. 2014).

While aquaponics has recently become more and more popular in the United States, with approximately 800-1200 home aquaponics systems and 1000 school aquaponics systems counted in a 2010 study, aquaponics could be even more beneficial to the people of the Bahamas (Love et al. 2014). Due to the aforementioned land issues as well as the limited availability of land, soilless aquaponics systems could provide large amounts of fish and fresh produce in small areas Bahamas (Somerville et al. 2014). Domestic agricultural production could help the Bahamas reduce their trade deficit as well as providing food security for Bahamians. Domestic food production would also reduce the amount of resources used for food to travel from its foreign source to distributors in the Bahamas (Somerville et al. 2014).

In regards to the negative aspects of aquaponics, there are comparatively few in relation to the benefits. They include the expense of the initial start-up costs, which would vary based on the size of the system, the system operators needing some knowledge of fish and plant care as well as training on the maintenance of the system, and an absolute need for reliable electricity. If an air or water pump shut off for just a few minutes, many fish could potentially die. The food produced by aquaponics system also does not represent a complete diet and would need to be supplemented from other sources (Somerville et al. 2014).

Despite potential obstacles, there has already been some movement towards adopting aquaponics in the Bahamas. At the Center for Sustainable Development on the island of Eleuthera, an aquaponics systems has been operated successfully using a floating raft setup that produces basil, mint, lettuce, and tomatoes, as well as Nile tilapia (Bowleg 2016). The system also uses captured rainwater and a gravity flow system that above plants that grow on the ground, providing those plants with shade. passively moves the water from the fish tanks to the plant beds, reducing the amount of electricity necessary to run the system. The Center for Sustainable Development along with the Cape Eleuthera Institute promotes aquaponics with outreach at local events as well as with the setup of an aquaponics system at the nearby Deep Creek Middle School (Bowleg 2016).

There has also been a 65,000 square foot aquaponics system installed at the Bahamas Agriculture and Marine Science Institute (BAMSI), where instruction has been given for the past three years. The institute touts itself as "providing strong academic training and extensive hands-on orientation in crop and livestock production, farm management, environment conservation, agri-business, and management of marine resources" (BAMSI 2015).

BAMSI is one recent initiative in the Bahamas intended to increase domestic agricultural production. With an aquaponics system present in the curriculum, graduating students could leave the institute with the technical knowledge to operate and maintain an aquaponics system. Hopefully, this will encourage these students to invest in their own aquaponics or other agricultural ventures. The Bahamas Agricultural and Industrial Corporation is an organization within the Bahamian government that works to further agricultural interests. In order to encourage the expansion of aquaponics and other sustainable agriculture systems, the BAIC could implement grants or loans for small farmers as well as potentially providing land. Tax breaks could be given to farmers as well to incentivize food production.

DISCUSSION OF PERMACULTURE

Permaculture is a recent development in agriculture and is described by one of its creators as "consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fibre and energy for provision of local needs" (Ferguson and Lovell 2014). Permaculture draws inspiration from naturally-occurring ecosystems in the local area and basing the crops planted off of those ecosystems. The most readily noticeable innovation of permaculture is that multiple levels of crops are typically grown in the same area. For example, fruit trees can be planted

At the Cape Eleuthera Institute (CEI), there is a permaculture farm drawing on these basic principles. Another important aspect of the farm at CEI is the use of compost to supplement the poor Bahamian soil. CEI attempts to be a no-waste campus and does so in part by gathering food scraps at every meal to be used for compost.

Figure 6. Part of the permaculture farm at CEI.

The main obstacle to increased permaculture in the Bahamas is the lack of soil resources. Though permaculture is more beneficial to the local environments because it mimics the natural ecosystems in place, there is still a need for adequate soil resources. While CEI is able to amass a large amount of compost, smaller operations would not be able to accumulate as much, leaving them with fewer resources for supplementing the soil.

While permaculture is certainly more sustainable than most modern agricultural methods, it will not be the primary solution for the Bahamas' agricultural woes.

CONCLUSIONS

While the three methods discussed in this paper are all better options for the Bahamas than industrial agriculture, aquaponics may provide the most benefit. This is because a system can be set up anywhere and does not require arable land or soil, two resources lacking in the Bahamas. Because the Bahamas is an island country, a large portion of the diet of both natives and tourists comes from seafood. Aquaponics systems could provide the Bahamas with another source of fish that does not put stress on marine fisheries.

The Bahamian government can encourage further growth of aquaponics and other sustainable agriculture endeavors in the Bahamas through the continued support of the Bahamas Agriculture and Marine Science Institute. Grants, short-term loans, and tax incentives should also be considered to provide financial support to potential adopters of the technologies.

Sustainability has become an important goal for many countries around the world. For the Bahamas, a domestic food source would dramatically increase their sustainability both environmentally and economically. While many steps have been made in the right direction, the Bahamas still has a ways to go on the path to sustainability.

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