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Bahamian Agriculture's Potential Effects on Coastal Ecosystems and Economy

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ABSTRACT

To increase food security, the Bahamas needs to expand its agricultural industry. However, the monoculture practices used in the United States have the potential to contribute to dead zones. Dead zones forming as a result of eutrophication can be caused by nitrogen runoff from agricultural fields. The formation of dead zones in the Bahamas has the potential to damage the tourism and fishing industries of the economy. Cuba has demonstrated that monoculture on an island creates nitrogen runoff as well as decreases food security. Cuba's renovation of their agricultural system sets an example for the Bahamas on how to promote sustainable agriculture. By using sustainable farming practices such as hydroponics, aquaponics, green manure crops, and distancing fields from streams, the Bahamas can develop their food security while avoiding the creation of dead zones.

INTRODUCTION

Bahamian agriculture is small-scale compared to the United States', producing $36 million of agricultural products as compared to America's $228 billion in 2012 (Food and Agriculture Organization of the United Nations, 2015). The Bahamas is attempting to expand their agricultural industry to increase their food security, as they import around eighty-five percent of their food annually (Food and Agriculture Organization of the United Nations, 2009). If the Bahamas were to follow the monoculture system of the United States, like other Caribbean countries have in the past, the consequences to the economy could be devastating. (Food and Agriculture Organization of the United Nations, 2009; Gonzalez, 2003). The large yield of the United States' agriculture produces high levels of agricultural nutrient runoff. The Corn Belt, a highly productive farming area, ranging across the Midwest, is famous for its mass production of corn. To keep this massive yield up, farmers must apply 8.7 million tons of fertilizer to their corn annually (United States Department of Agriculture Research Service). While some of the nutrients from the fertilizer are absorbed by the crops, eighty-three percent of the nitrogen applied escapes the soil, some seeping into the groundwater and make their way to the Mississippi River as agricultural runoff (Horrigan, L. et al., 2002; Fowler, 2013). The river carries all of these nutrients to the Gulf of Mexico, resulting in a eutrophication event creating a 6,400 square mile span of lifeless waters, commonly referred to as a dead zone (Environmental Protection Agency, 2016).

If the people of the Bahamas follow the agricultural practices that Midwest American farmers have put in place, the agricultural runoff has the potential to affect them directly by destroying their coastal marine ecosystems. Their tourism and fishing industries are heavily dependent on the health of their coral reefs, which poses a potential for economic damage. If they instead followed Cuba's example of a sustainable Caribbean agricultural industry, they could avoid the possibility of dead zones forming around their islands. Sustainable agricultural practices already present in Cuba could be implemented in the Bahamas while the agriculture industry is still small-scale, avoiding agricultural nutrient runoff while avoiding farmers' loss in yield and profit.

The focus of this paper is to identify the potential threat to the ecosystems and economy of the Bahamas posed by agricultural nutrient runoff from industrial agriculture. The agricultural developments of the similar nation of Cuba and the effects on their environment will then be reviewed. Finally, sustainable agricultural systems and practices will be examined to determine how to best combat the threat of agricultural nutrient runoff while allowing the agricultural sector of the Bahamas to grow and contribute to the economy and food security of the nation.

AGRICULTURAL NUTRIENT RUNOFF

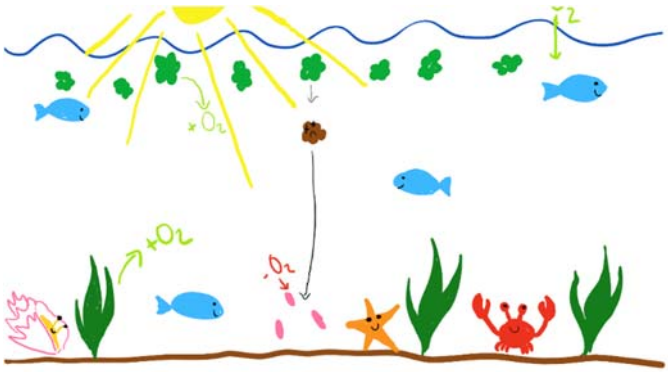
The monoculture of the United States produces a high yield of products, but leads to the depletion of soil nutrients, nitrogen in particular (Liu, 2010). To counteract this depletion, farmers apply nitrogen fertilizers to their crops. (Fowler, 2013). Only seventeen percent of the nitrogen applied is used by the crops; the rest escapes either into the atmosphere or nearby rivers through agricultural runoff and leeching (Fowler, 2013; Ribaudo, 2011). Nitrogen in rivers will follow the flow of the river, eventually emptying into the ocean. The addition of nutrients to a marine ecosystem is a process called eutrophication and is the leading cause of dead zones (National Oceanic and Atmospheric Administration, 2014).

EUTROPHICATION AND DEAD ZONES

Dead zones are the result of eutrophication events leading to hypoxia in marine waters near the mouths of rivers (Roberts, 2012). In a healthy ecosystem, as shown by Figure 1, algae feeds off of the nutrients naturally deposited by the river. The algae provide oxygen to other organisms at the surface through photosynthesis. As the algae die, their bodies fall to the seafloor, where they are decomposed by bacterial communities. This process of decomposition consumes oxygen, but plants on the sea floor replenish the oxygen by photosynthesizing (Roberts, 2012).

When eutrophication occurs due to agricultural nutrient runoff, more nutrients become present in the surface water (Roberts, 2012). The abundance of nutrients provides the algae with a surplus of food, and the population will proliferate. When enough nutrients are present, the algae will become too thick for sunlight to penetrate. Consequentially, the plants on the seafloor die. The increase in algae populations results in escalated amounts of dead algae, causing the decomposition rates of their bodies to amplify. Without the plants to offset the oxygen consumption of the bacteria, the oxygen levels on the seafloor plummet. This process is referred to as hypoxia and is displayed in Figure 2.

Figure 1. A healthy ecosystem where an appropriate



amount of algae provides oxygen to the surface and allows sunlight to reach plants on the seafloor to produce oxygen, counteracting the consumption of oxygen by the bacterial decomposition of dead algae.

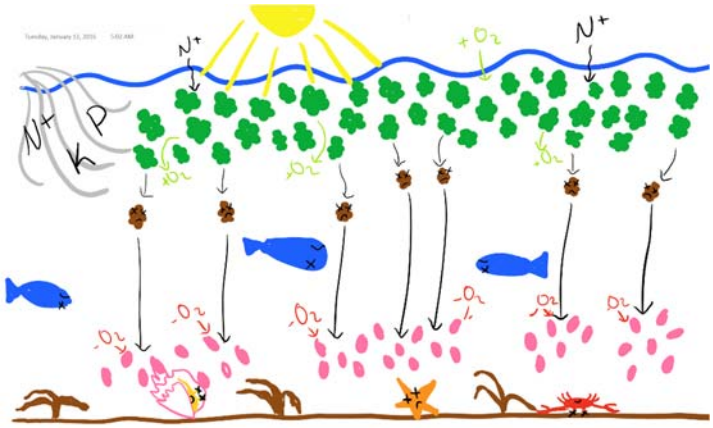
POTENTIAL EFFECT ON THE BAHAMAS

The presence of dead zones in the Bahamas could be devastating to the country's economy. Tourism makes up fifty percent of the Bahamas' GDP (Inter-American Institute for Cooperation on Agriculture, 2007). The tourism in the Bahamas is based around its beautiful beaches and ocean waters. If dead zones were to form, the water would become ridden with massive algal populations as seen in *Figure 3*, deterring most, if not all, of the tourists visiting the area. It is difficult to estimate the exact monetary effect dead zones would have on the economy, since it would depend on if the dead zones formed in highly-traversed waters or not. To prepare for the worst possible scenario, it could be estimated that if dead zones began to form in popular tourist areas, the tourism could decrease by fifty percent. That would equal twenty-five percent of the Bahamian industry—almost $2 billion (The World Bank, 2014).

Additionally, fishing made up one percent of the Bahamas' GDP in 2009 (Food and Agriculture Organization of the United Nations, 2009; The World Bank, 2014). Dead zones would be extremely detrimental to the fishing industry, killing most of the valuable fish populations. Spiny lobster and conch make up ninety-one percent of the fishing industry

(Food and Agriculture Organization of the United Nations, 2009). Unlike fish, these animals do not have the ability to migrate quickly enough to escape hypoxia, so their populations are likely to become extinct in areas affected by dead zones (Roberts, 2012). The extinction of these species in Bahamian waters would result in a loss of seventy-three million dollars annually (Food and Agriculture Organization of the United Nations, 2009). Additionally, the loss of the fishing industry would further increase Bahamian dependence on food imports.

Figure 2. An ecosystem exposed to eutrophication where the influx of nutrients has caused the algal bloom to become so thick that light does not reach the plants on the bottom, resulting in bacteria using up all the oxygen without plants replenishing it.



The combination of effects on the tourism and fishing sector could amount to twenty-six percent of the GDP vanishing. Losing this amount of income would be a catastrophic economic event, making it essential for the government of the Bahamas to takes steps towards promoting sustainable agriculture now to avoid the formation of dead zones.

EXAMPLES OF AGRICULTURE IN THE CARRIBEAN

The Bahamas can look to historical evidence of the effects of monoculture versus sustainable agriculture, and use these examples to structure their transition to more sustainable methods. A useful example is the country of Cuba, also located in the Caribbean. In the eighteenth century, Cuba followed a monoculture system similar to that of the United States, with sugar cane and coffee making up seventy percent of their total agricultural value (Gonzalez, 2003). The Soviet Union consisted of eighty percent of Cuba's foreign trade. This dependency proved to be deadly, as during the Cuban Revolution the country experienced mass food shortages, with average caloric intake dropping by thirty percent. After the revolution, the government promoted the development of a stronger agricultural sector to improve food security. The agriculture they promoted was predominately monoculture and relied heavily on the usage of fertilizers. Within thirty years the usage of fertilizer grew to be ten times that of before the revolution. These levels of fertilizer lead to the pollution of water that has the potential to create dead zones. Luckily, the Cuban government decided that a change needed to be made to improve the country's food security and environment (Gonzalez, 2003).

Figure 3. Algae blooms in China's Yellow River due to eutrophication events.

After experiencing the effects of monoculture, Cuba transformed their agricultural industry into a system based on sustainable farming practices (Gonzalez, 2003). The Cuban government divided previously state-owned farms into small privately-owned farms. This change in ownership allowed for a larger number of farms to be operated on a smaller scale. Private owners of small farms were not dependent on fertilizers, and could grow a wide variety of crops. The use of green manure crops was also promoted. Green manure crops reduce the nitrogen that is lost into the groundwater, as well as providing more available nitrogen for future crops (Thorup-Kristensen et al., 2003). Organic fertilizers such as animal waste and crop residues were used, making it easier to not load the fields with excess nitrogen (Gonzalez, 2003).

The results of the transitions to sustainable farming benefited the food security of Cuba as well as the environment (Gonzalez, 2003). The new diversity of crops resulted in greater soil quality compared to the monoculture formerly used. The system is more ecologically sustainable than traditional systems, as the green farming methods require less fertilizer.

Additionally, the newly-founded small-scale farmers became very successful, as the shortage of food imports created an increased demand for agricultural products (Gonzalez, 2003).

SUSTAINABLE AGRICULTURAL PRACTICES

To ensure a low amount of nitrogen runoff is created by the expansion of the Bahamas' agricultural sector, the government will have to promote sustainable agricultural practices. Following the example of Cuba by using green manure crops and organic fertilizer could be beneficial, but there are modern techniques that are even more ecologically sustainable.

Hydroponics is an ecologically sustainable system where plants are grown in nutrient-infused water instead of soil (Jones, 2004). The plants are grown in a closed system, so no water is released into the environment. Another system similar to hydroponics is aquaponics. Aquaponics grows crops in a hydroponics system while simultaneously raising fish in tanks (Rakocy, 2006). Fish waste is filtered from the fish tanks to the water that the plants grow in, and the plants are fertilized by the nutrients. Once the plants remove the waste from the water, the water can be circulated back to the fish tanks. Like hydroponics, this closed system will not contribute any nitrogen runoff to the environment. This system has potential to not only bring farmers profit through crops, but through fish production as well. The high demand for seafood in the Caribbean provides an ideal market for farmers to sell their fish (Food and Agriculture Organization of the United Nations, 1989).

In addition to these alternative agriculture methods, the traditional farming methods can be altered to be more ecologically sustainable. A study conducted off the coast of Canada demonstrated that if fields were positioned ten meters away from a steam resulted in a fifty-two to ninety-eight percent decrease in nutrient concentrations in the stream within thirty meters, as opposed to fields located directly next to the steam (Dunn et. al, 2011). Likewise, fields twenty meters away from a stream resulted in a sixty-eight to one hundred percent decrease in nutrients present in the stream.

CONCLUSIONS

To increase the food security of the Bahamas, the agricultural sector needs to be expanded. However, it is essential that sustainable agriculture be used when promoting the growth of agriculture. The production of agricultural nutrient runoff has the potential to create dead zones that could result in a loss of twenty-six percent of the country's GPD. To minimize agricultural nutrient runoff, the government must provide an incentive for farmers to use sustainable methods. Laws can be put in place stating that all fields must be located twenty meters away from any streams. Governmental compensation can be given to help farmers with the start-up costs of hydroponics and aquaponics systems. To increase overall food security, a tax should be put on imported food. Such a tax will increase the demand for food grown in the Bahamas, giving Bahamian farmers an advantage while influencing the public to support Bahamian farmers. If these methods are enforced, the Bahamas has the potential to increase their economy, food security, and ecological sustainability simultaneously.

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