Hydroponic Crop Cultivation as a Strategy for Reducing Food Insecurity

Globalization of Agriculture and its Effects on Small-Scale Farmers in Haiti and Jamaica

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Agriculture continues to play a primary role in the economy of the Caribbean. Presently, the agricultural sector of the region is much more diverse due to the reformation of agriculture policies in the European Union which caused a dramatic decrease in the demand for Caribbean export crops. While agriculture is not extremely prevalent in all countries in the region, countries such as Haiti, Dominica, Guyana, and Grenada have large agricultural sectors which contribute to 7% to 17% of total Gross Domestic Product and between 10% to 50% of employment (Food and Agriculture Organization [FAO], 2019). Despite this, the region is currently a net importer of food averaging between 60% to 80% imported. The remainder of food is supplied by small-scale farmers (Graham, 2012). This difference has arisen in the past 40 years due to increasing globalization causing local food sources to become unable to compete with industrial agricultural operations in places like Brazil (Barker, 2001). The Food and Agriculture Organization defines small-scale farmers based on being in the bottom 40% of land ownership and economic revenues at a national level (FAO, 2018). In the Caribbean, small-scale agricultural work is mostly dominated by males with the primary age range of 41-54 years old. Females often join the system around the age of 30 with primary roles in harvesting and selling the crop (Graham, 2012). Crops are often sold locally providing to local nutrition and livelihood (Beckford & Campbell, 2013). Most small-scale farms are found in rural areas which generally have lower incomes. Their lower income and the reliance on imported food for a majority of their nutrition leaves these people vulnerable to economic and environmental factors that can eliminate their access to healthy foods (Graham, 2012).

Food security is when people have easy social, physical, and economic access to the food that meets their dietary needs and preferences at all times (IPCC, 2021). In 2019, it was

estimated that around two billion people in the world do not have access to safe and nutritious food. Furthermore, around 750 million people, or about one in every ten people in the world, were exposed to severe levels of food insecurity. These numbers are expected to grow by nearly sixty million people in the next five years (United Nations, n.d. a). Food insecurity comes in many forms; an especially prevalent issue is micronutrient deficiency, or 'hidden hunger', which impacts one in three people globally (IPCC, 2021). Micronutrients are vitamins and minerals needed in small amounts which are critical to the body to perform a range of functions and deficiencies are disproportionately found in low- and middle-income countries (World Health Organization, n.d.).

Current food systems in place face pressure from non-climate stressors such as population growth, demand for animal products, and availability of fertile soil as well as climate stressors. In the next century, climate change is projected to negatively impact the four pillars of food security – availability, access, utilization, and stability. Human induced climate change caused by carbon dioxide (CO_2) emission exacerbates the current stresses on these pillars through increasing temperatures, changing precipitation patterns, and the increase in frequency, duration, and intensity of extreme weather events like floods, droughts, and hurricanes (IPCC, 2021). Small-scale farmers in Small Island Developing States (SIDS) are especially vulnerable to the impacts of climate change on food security. SIDS are located in the Caribbean, Pacific, Indian Ocean, and South China Sea and make up approximately 1% of the world's population (United Nations, n.d. b). These populations face unique challenges due to their small land area, remote geography, and susceptibility to extreme climate events (Taylor et al., 2012). This project seeks to develop a novel hydroponic cultivation design that will help small-scale farmers

in the Caribbean restart production after extreme climate events, and later I will seek to answer how the globalization of agriculture is affecting small-scale farmers in this region.

Designing a Floating Hydroponic System

Currently in the Caribbean, nearly all rural households are small-scale farming operations. These households often have a traditional attachment to the land and farming on it. Since these operations are independent, there is no dominant small-scale farming system in place (Graham, 2012). Farmers use a range of traditional methods like intercropping which is when two or more crops are grown within close proximity of each other with the goal of producing a greater yield of crops by utilizing resources that would not be taken advantage of by a single crop. This practice has numerous benefits such as erosion reduction, filtering pollutants from the soil, and slowing runoff (Natural Water Retention Measures, 2015). Some small-scale farmers also use contemporary methods like greenhouse technology and organic farming to increase the value of their yield. However, many crop farmers also use agri-chemicals like fertilizers and pesticides which have been shown to harm the environment (Graham, 2012).

The focus of this technical project is to design and develop a prototype of a hydroponic crop cultivation unit that is capable of floating on water. Hydroponic crop cultivation is a method of farming in which plants are grown in a nutrient solution instead of soil. This decreases the amount of water used by up to 90% and significantly increases the yield per area (Benefits of hydroponics, 2021). Hydroponic systems are also often able to decrease the growing time needed to produce mature crops. Within the scope of hydroponics, there are many different types and designs of systems. Different types of systems are made to optimize the use of different variables such as land and water use and growing time. The design of features in hydroponic systems like

the area for roots to grow, how much weight the structure can support, and the physiological requirements of the plant determines what type of hydroponic system is best for the application (Yuvaraj & Subramanian, 2020).

This project will use a method of hydroponic cultivation called Dutch Buckets. In this type of system plants are grown in large pots with their roots in a clay pellet and perlite mixture. The pots are positioned alongside a pipe which distributes nutrient solution through a drop system into the root systems of the plants. The nutrient solution is pumped from a reservoir which will also have rainwater collection capabilities so that in the event of flooding or other instances of possible water contamination the crop will be unaffected. Excess solution that is added into the pots will be collected in a pipe underneath and returned to the reservoir ("Dutch Buckets", 2020). The Dutch Bucket system will be housed on a platform which is capable of floating and withstanding some hurricane conditions. The system will be completely solar powered and only need minimal maintenance such as monitoring the water pump and adding nutrient solution to the circulating water. This floating farm design will allow food production to be quickly restarted after or uninterrupted by an extreme weather event such as flooding or a hurricane.

The floating hydroponic crop cultivation unit will initially serve small-scale farmers in SIDS who are in areas highly susceptible to extreme weather events and lack food security in catastrophic events. Initially, the floating farm units will not be able to be the primary food supply after a disaster but they are meant to provide a supplement to disaster relief rations supplied by aid organizations. The main crops grown in the systems will be vegetables that are high in micronutrients. This will ensure that the people have access to fresh and nutrient rich vegetables in the wake of a disaster. In the region, the average importation of food into countries

in the regions is as high as 60% and on a sub-regional average up to 80%. This leaves communities extremely vulnerable to instabilities in domestic food prices and also to interruptions in the imported food supply chain due to extreme natural events like hurricanes. These factors are especially dangerous for poor and marginalized communities (Graham, 2012). Though the technical portion of this capstone focuses on designing a floating hydroponics system, the remainder of this project explores how the globalization of agriculture is affecting small-scale Caribbean farmers.

Socio-Technical Topic

Due to their scale, industrial farms are able to produce massive volumes of produce at a low price. However, this comes at a cost to the quality and diversity of what they can produce. In addition, the concentration of production creates more risk for the supply chain if these regions are impacted by an extreme natural event. Individual small-scale farms face this same risk but since they are independent, the supply of food is not likely to be at risk due to a single event. Small-scale farms are better able to meet shifts in demand and promote biodiversity, however, their smaller scale also leaves them less likely to be able to adopt the newest farming technology (Luzzini, 2019). Since the goal of this new technology is to provide disaster relief and to empower small scale farmers, it is important to consider the distribution of the technology.

Increasing the local agricultural capacity by empowering small-scale farmers through the use of high yield hydroponic systems could potentially increase the participation of women in land owning agriculture. Currently, there are many barriers of entry for women to own enough land to farm on (Barry & Gahman, 2021) however, hydroponics would reduce the amount of land needed to begin cultivating crops.

The empowerment of small-scale farmers in the Caribbean will also strengthen the development and community of rural areas. Small-scale family farms are an important part of the cultural and ethnic identities of the region. By remaining in the rural areas, members participate in active social lives with the surrounding communities which preserve the cultural aspects of the region like the language, cuisine, and folklore. Currently, there is an increasing pressure from corporate sectors to purchase land in rural areas for land acquisition, access to mineral reserves, and space for commercial services. The mining sector in particular has caused instances of land grabbing which causes small-scale farmers to be forced to sell their land or have their lands be impacted by the waste from the mines. Supporting small-scale farmers will allow them to resist these foreign pressures so that the cultural identity of the rural areas can be preserved (Schneider, 2016).

This paper will use the framework of neo-colonialism to analyze the impacts of industrial agricultural practices on small-scale farmers in the Caribbean. Neo-colonialism is the regressive use of economic, societal, or other pressures by former colonial masters and powerful nations to control the development and prosperity of another country (Segell, 2019). Part of neo-colonialism is the dismissal of local perspectives and traditions in order to promote activity that is beneficial for the neo-colonizer. In the paper "Responsible innovation as empowering ways of knowing", Valkenburg et al. (2019) discuss the importance of responsible research and innovation (RRI) in these areas. The goal of RRI is to make the governance of science, technology, and innovation easier to access for the groups that they represent and to empower people to contribute their own knowledge and ontologies. Within RRI, 'inclusion' and 'responsiveness' are key factors which encourage knowledge inclusion participants. The authors make a point to differentiate social inclusion from epistemic inclusion. Social inclusion consists

of ensuring that people are able to overcome economic, political, and social barriers that prevent participation in governance processes. Epistemic inclusion deals with ensuring a group of actors with different backgrounds and knowledge bases can meaningfully contribute to innovation and governance. The idea of inclusion assumes a core site where decisions about governance of innovation occur and a voiceless periphery (Valkenburg et al., 2019). The authors relate this back to the idea of unmarked categories from Haraway's 1988 "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective". Unmarked categories consist of the dominating class who is privileged enough to define the classes of society and determine how they matter while remaining exempt from classification themselves (Haraway, 1988).

Valkenburg et al. use an example of Indian farmers and their resistance to biogasification to illustrate an implantation of RRI. In this example, the farmers needed to burn excess straw from their fields from the wheat harvest in order to plant rice in time. Burning the straw creates harmful pollution that drifts into the cities so it was proposed by a large chemical corporation that the excess straw be used in a biogasification process to generate electricity. This solution did not include the knowledge of farmers and ignored that their primary need was to clear the field, not discard the waste. The perspective of the farmers who were kept on the periphery of governance of innovation was fundamentally different from those who proposed the innovation (Valkenburg et al., 2019). This fundamental disconnect between the apparent 'core network' and the 'periphery' will be illustrated in the reinforcement of the neo-colonial relationships between the global agriculture industry and small-scale farmers in the Caribbean (Girvan, 2012).

Research Question and Methods

I will answer the question: How is the globalization of agriculture impacting small-scale farmers in Caribbean SIDS, specifically, Haiti and Jamaica? This topic is essential to understand the neo-colonial relationships of these nations to other countries and how nations in the region are benefiting or being harmed by these relationships. This will inform policy makers and researchers of areas that need to be adapted in order to practice RRI principles.

To provide evidence for the research question, I will analyze agricultural case studies and agricultural policy from Haiti and Jamaica. This analysis will show how the industrialization of cash crops like sugar and coffee is impacting small-scale farming practices in the region. I will be looking to see how the culture, health, and economic prosperity of small-scale farmers is impacted by changes in practice. By investigating agricultural policy of the region, I hope to discover how the governments in the region are or are not influenced by other countries to develop the agricultural policy in certain directions.

In order to address RRI, I will also perform a bibliographic analysis in order to identify how Haiti and Jamaica benefit from North-South collaboration and which may be victim to neo-colonialism. To conduct this analysis, I will be using the Web of Science to search for articles pertaining to agriculture Haiti and Jamaica since they are two of the larger nations in the region with about half of their land used for agriculture. This data will include the authors' names, sponsoring institution, nationality, gender, keywords, number of citations, and the year published. Once this data is gathered, it will be analyzed to determine if there is significant collaboration between native Caribbeans and 'northern' researchers. Analysis on the relative impact of articles based on the number of citations will also be conducted. This analysis will begin to determine whether there is an epistemological divide between what might be considered the 'core networks' of the global north and the Caribbean researchers.

Conclusion

Small-scale agriculture in the Caribbean is being threatened by the globalization of agriculture. A decreasing number or complete loss of small-scale farmers in the Caribbean would be detrimental for the food security, culture, and society of the region. For these reasons, the impact of the globalization of agriculture on small-scale farms in the Caribbean will be analyzed using a neo-colonialism framework with focus on responsible research and innovation. The case studies and policy analysis will likely conclude that small-scale farmers are being pushed out by larger industrial farms. The bibliographic analysis will likely show a dominance of northern researchers in the literature and cited literature about the topic showing that there is an epistemological divide.

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