A FLOATING FARM FOR HYDROPONIC CROP CULTIVATION

THE EFFECTS OF HYDROPONIC FARMING ON SURROUNDING COMMUNITIES

A Thesis Prospectus
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Bachelor of Science in Systems Engineering

By
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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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Hydroponic farming is a way to produce crops in an efficient manner that does not waste space or water. This type of farming method can often yield more crops than conventional farming methods and also produce crops throughout the year rather than being seasonal (Treftz & Omaye, 2016, p. 672). There are many reasons having a stable method of growing crops is important, but some of the main reasons are increasing demand for food worldwide, malnutrition, and helping to provide a stable economy (Treftz & Omaye, 2016, pp. 672-673).

The two topics of this research are, creating a floating hydroponic farm to survive hurricanes in the Caribbean, the technical discussion topic, and how hydroponic farms affect the communities that surround them, the STS research topic. These two tightly coupled topics, relate to each other as the technical portion of the research goes over how a hydroponic farm can be made to be stable, secure, and survive in areas that have an environment too harsh for conventional farming, while the STS research portion discusses how the implementation of a hydroponic farming system can benefit communities and society by providing more crops to combat malnutrition in areas where nutrient dense food is scarce, and allow the users of the system to further the economy by selling crops and using the land that is spared by the implementation of the system to develop more small businesses.

Figure 1 on page 2 shows the timetable for the work that will be carried out over the course of the Capstone project. Each of the times that the deliverables have been labeled to be carried out are estimations and may change over the course of the project.

Task Name	Duration	Start	Finish
Preliminary	**31 days**	**Mon 8/29/22**	**Mon 10/10/22**
Primary Objectives	**141 days?**	**Wed 10/5/22**	**Wed 4/19/23**
Determine Guidelines for grading	1 day	Tue 10/11/22	Tue 10/11/22
Structural	**87 days?**	**Wed 10/5/22**	**Thu 2/2/23**
Model the system	**49 days?**	**Mon 11/28/22**	**Thu 2/2/23**
Make sure the vessel is structurally sound during CAT III storms	1 day	Tue 1/30/23	Tue 1/30/23
Water Storage & Acquisition	**84 days**	**Tue 10/11/22**	**Sat 2/4/23**
Grow Crop in the System	**62 days**	**Tue 1/24/23**	**Wed 4/19/23**
Finding the niche where this system can best be adapted	**97 days?**	**Mon 10/10/22**	**Wed 2/22/23**
Complete Final Report	15 days	Mon 3/6/23	Fri 3/24/23

Figure 1: Timetable of Capstone Project Deliverables. This figure depicts the timeline for the deliverables of this Capstone project. Shown are the estimated start and finish dates, along with the estimated duration and predecessors for each deliverable of the project. (Thurmond, 2022).

A Floating Farm for Hydroponic Crop Cultivation

Worldwide, some of the most at-risk regions for food insecurity are coastal communities and Small Island Developing States (SIDS) (includes nations in the Caribbean, Pacific, and Indian Ocean) due to a variety of natural and economic factors. Making up approximately 1% of the global population (UN, 2022), SIDS face unique challenges due to their small land area, remote geography, and susceptibility to extreme climate events. Current food systems in place face mounting pressures from population growth, availability of fertile soil as well as an increasing rate of extreme weather. According to the UN, climate change is projected to negatively impact the four pillars of food security, availability, access, utilization, and stability, during the 21st century (UN, 2021). Climate change is exacerbating 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. The goal of our capstone group's project is to provide a functional product that helps create sustainable food sources in Caribbean SIDS where there are frequent high risk natural disasters such as hurricanes and floods. Specifically, this project will be a crop cultivation system that is a mostly self-sufficient sustainable food source, withstands extreme weather and associated hazards, and provides supplementary power supply when necessary.

While the effects of climate change will affect every nation, region, and economy of the world, Caribbean SIDS are especially vulnerable due to their close connection to coastal environments. According to the University of the Bahamas, global mean sea-level is currently rising at a rate around 3.6 mm per year (Baptiste et al., 2020, pp. 3-7). This rate only increases with higher emission scenarios with possible meters of sea level rise by 2300. This is detrimental for the future of coastal communities that support tourism, fisheries, and agriculture industries in the region. SIDS are also vulnerable to extreme weather events which have been exacerbated by the changing climate. These weather events can result in damage at a nationally significant scale since Caribbean SIDS have small economies, areas, and populations. In 2017, Hurricane Maria caused damages that amounted to more than 225% more than the annual GDP of Dominica (Baptiste et al., 2020, pp. 3-7). Agriculture plays a primary role in the economy of Caribbean nations with several nations having large agriculture sectors which contribute to upwards of 20%

of their total GDP. Despite their large production capacity of agriculture, most countries in this region are highly dependent on food imports (FAO, 2019). Caribbean SIDS have greatly increased the amount of food imported into the region. Since 1990, the proportion of consumed food that is imported has risen from 40% to 60% with over half of countries importing over 80% of their food (Hickey & Unwin, 2020, pp. 1-4). A higher reliance on imported food coupled with intensifying natural disasters due to climate change, adds volatility to markets and increases food instability. Currently in the Caribbean, many rural households are small-scale farming operations or have some food production capabilities. These households often have a traditional attachment to the land and farming on it. Since these operations are independent, there is no larger small-scale farming system or organization in place (Graham, 2012, pp. 29-31). This project hopes to reduce local food instability by allowing local farmers from SIDS to increase their total in-country food production by increasing total resiliency from weather events.

The 2018-19 capstone team modified an existing HCC technology to create the Fold-out-Farm for post-hurricane recovery in Small Island Developing States (SIDS), particularly in the Bahamas. The next three capstone teams, ranging from 2019-2022, modified the design to float and operate with solar panels. Figure 2 below shows the most recent design of the 'Fold-out-Farm'. The model is an 8x8 foot square platform that holds a hydroponic Dutch bucket system and electrical equipment. Trapezoidal storm doors fold inwards by 45 degrees, protecting the electrical and

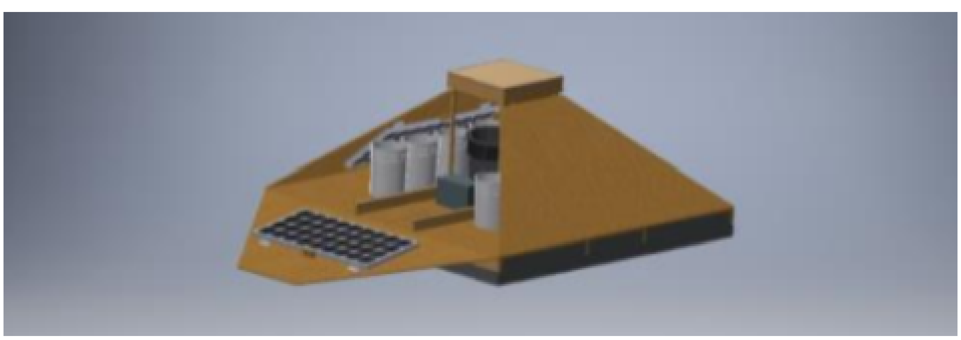

Figure 2: Floating platform AutoCAD model, partially folded: An overview of the current system depicting one of the trapezoidal panels unfolded. (Boland et al. 2022).

hydroponics systems (Boland et al., 2022, p. 3). Our capstone team consisting of members Ethan Gerlach, Arthur Hoang, Saffiata Kamara, Anwar Longi, Derrick Sprincis, Ethan Thurmond, and advised by Garrick E. Louis, Associate Professor in the Department of Systems and Environmental Engineering, will be building on the previous work of these teams by adding a rainwater harvesting or desalination system to the existing model so that a water supply is available for the crops in an emergency. Our group's initial idea for the rainwater collection system is a funnel that can filter rainwater, with the size of the funnel calculated by how much water the reservoir of the system can hold and how much water the system loses over time. Our second goal is to validate the feasibility of an HCC system under severe weather conditions such as hurricanes and strong winds. A computer-aided design (CAD) model is planned to be implemented to design an optimal model for resilience to strong weather conditions. Our third goal is to refine an existing market niche for HCC through contacting stakeholders in SIDS and seeing where the demand for this product is strongest. If we develop a solution to these problems, and have enough time, we will then be able to look into which nutrient solution to use, as certain nutrient solutions can yield better harvests for certain crops (Singh et al., 2019, pp. 4-8).

If successful, we will have a product ready to enter the market for use in SIDS. We would have addressed any flaws in the previous system while adding the new modifications addressed above. We plan to have our technical paper, a scientific paper, done during the Spring semester of 2023.

The Effects of Hydroponic Farming on Surrounding Communities

During the STS research discussion, the topic of how the advancement and implementation of hydroponic farming technology affects the local communities with respect to health and the economy will be discussed. This will be carried out by comparing aspects of conventional farming and hydroponic farming, as well as researching pre-existing articles on the topic.

The level of importance which hydroponic farming technology has to its local community increases with the world population's demand for food. Soil degradation continues to take away from suitable farming locations on our planet each year (Treftz & Omaye, 2016, pp. 672-673). This can cause the residents in locations near areas where the soil has been degraded to become malnourished, as has happened in regions such as Latin America and the Caribbean (Grajeda et al., 2019, p. 139). If hydroponic farming can be implemented in areas that do not have access to nutrient dense soil, it could potentially help combat malnutrition in those locations. Furthermore, according to Newell et al. (2021) hydroponic farming could allow local communities to spare more of the land that surrounds them, which would in turn increase biodiversity and habitat size for animals. With more land spared, local communities can create more businesses to further their economy as well.

As of today there is a significant amount of research and studies have been done to prove the benefits of hydroponic farming, however as previously mentioned, there is still an increasing demand for food and a high amount of malnourishment around the world (Grajeda et al., 2019, p. 139). Figure 3 on page 7 depicts the comparison of the yields from harvests from a hydroponic system versus conventional farming methods. The yield from the hydroponic farming method dwarfed the yield from the conventional farming methods by producing around 11 times as much lettuce as that of the conventional farming methods (Barbosa et al., 2015, pp. 6885-6888). Results such as these represent how much of an impact hydroponic farms could have on the communities they are implemented in and why further action and research needs to be conducted in order to allow these systems to be implemented into the regions that need them.

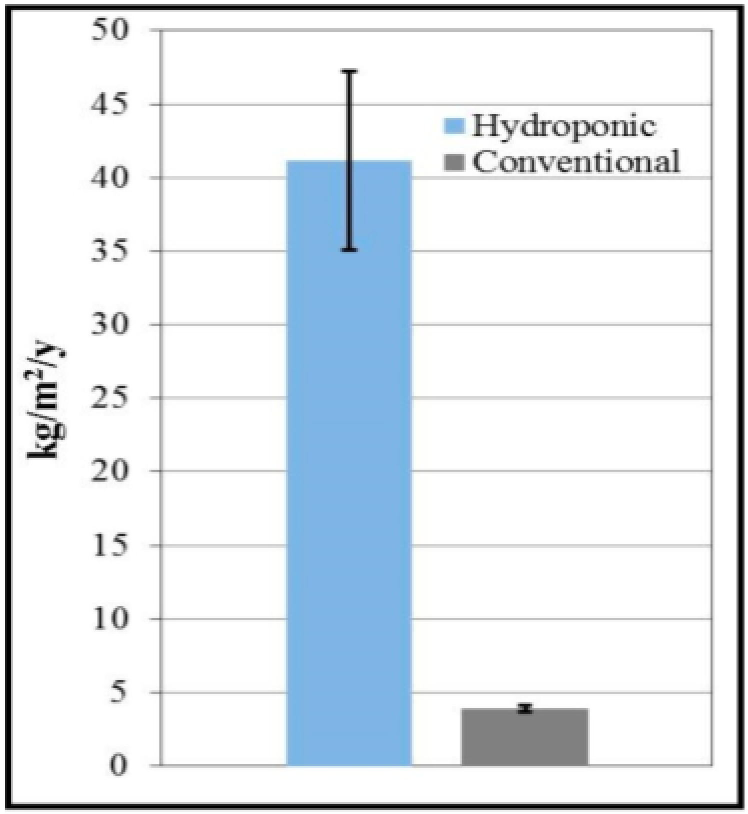

Figure 3: Hydroponic vs. conventional lettuce yield: Modeled annual yield in kilograms per square meter of lettuce grown in southwestern Arizona using hydroponic *vs.* conventional methods (Error bars indicate one standard deviation). (Barbosa et al. 2015).

This topic is tightly coupled with the technical project portion of this research as both are related to hydroponic farming. I anticipate that the scope of my research will include using pre-existing articles, and data to discover what hydroponic farms could do for or to a local community, and how that compares to conventional farming. The objective of this research work will be to gather multiple forms of evidence and information from the types of sources previously mentioned and comprise them all into a research paper in order to reveal the major potential benefits of hydroponic farming such as farming in regions without nutrient dense soil, improving access to nutrition to the regions around the system, and improving crop yield (Fecondini et al., 2010, p. 176).

This research will follow the General SCOT approach, as the technology of hydroponic farming does not develop independently from society by any means and both the technology itself and society influence and shape each other (Johnson, n.d., p. 1792). Figure 4 below shows the specific framework model that represents the hydroponic technology. The groups that negotiate and work with the engineer in the case of hydroponic farming would be people such as the farmers themselves who work with the system, the community that lives around the system, or even people that are not as directly involved with the system such as investors or companies that regulate the system (Carlson, 2009, p. 4). Since the hydroponic farm systems are ultimately implemented in the communities that will use them, it is very important that communication goes both ways between the engineer and the social groups during the design process to make sure that the system is usable and efficient when it gets implemented.

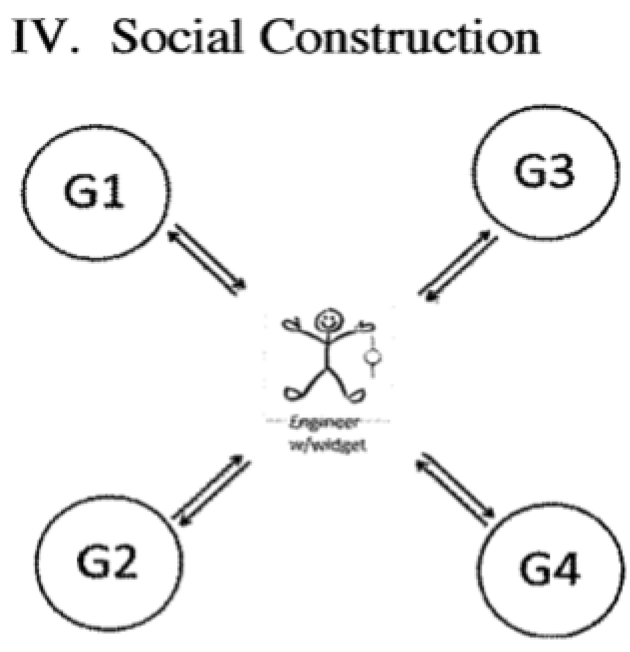

Figure 4: Social construction STS framework model: In this framework model, G1…Gn are groups which the engineer interacts with to design the system. Arrows go both directions to depict the negotiation between engineers and the groups. (Carlson, 2009).

The hoped-for outcomes of this research and the scientific paper that will be written from this research, is to help further depict and reveal the possible solutions to major problems around the world through the use of hydroponic farming.

A Strong Farm for a Strong Community

In conclusion, if a stable and structurally sound hydroponic farm was able to be implemented in areas that have trouble with conventional farming, whether that be storms or soil degradation, it could change the lives of the residents in local communities by supplying them with enough nutrition and allowing them to spare the land that would be used for farms. Furthermore, implementing hydroponic farms could not only help keep users healthy, but also improve their community economically by allowing farmers to yield more crops than a conventional farm would and ultimately sell them to help provide for themselves and their families financially.

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