A Floating Farm for Hydroponic Crop Cultivation
(Technical Paper)

The Implementation of Hydroponics in Northern Africa and the Middle East
(STS Paper)

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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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Introduction

Farmers in the Caribbean are constantly at in a state of food insecurity and along with the never-ending tropical storms this region struggles to provide for its people. Current farming techniques are highly susceptible to these natural disasters, leaving the people helpless. This requires new farming technique to be put in place in order that can withstand these disasters and allowing farmers to provide in their time of need. The final technical deliverable, a floating hydroponics farm, will allow farmer's crops to survive in these intense storms allowing the economy in the Caribbean to prosper without the constant fear of a disaster destroying everything.

On a slightly different note, with temperatures on the rise and the effects of global warming become more apparent, freshwater is becoming a luxury in certain areas of the world. Some areas are struggling more than others, 12 of the 15th world's most water scarce countries are in North Africa and the Middle East (Roudi-Fahimi & Creel, n.d.). Global warming is not stopping anytime soon and based on the current trend it is only expected to worsen. Annual water discharge is projected to drop by another 15–45% from an already difficult state (Waha et al., 2017). These countries must change their old ways of water use to adapt to this new crisis, including implantation of new technologies, water reallocation, education, etc. (Roudi-Fahimi & Creel, n.d.). Countless amounts of time and money are spent every day looking for a remedy to help farmers and the regular people to continue living the life they have. Hydroponics offers a solution to help battle and just to this problem. Hydroponics is a farming practice that in short summary does not use an artificial medium such as sand. The technology grows its plants in a nutrient rich solution and is usually implemented in greenhouses. Hydroponics offers high yield,

while it conserves water and protects the environment (Jensen, 1997). This technology could potentially offer some economic along with political relief in this region.

Technical

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 my 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. 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 1 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 hydroponics systems (Boland et al., 2022, p. 3). My capstone 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 investigate which nutrient solution to use, as certain nutrient solutions can yield better harvests for certain crops (Singh et al., 2019, pp. 4-8).

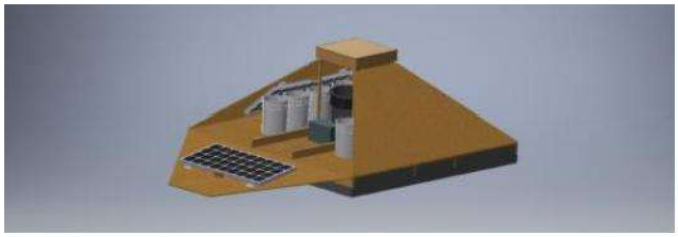

Figure 1: Floating platform AutoCAD model, partially folded: An overview of the current system depicting one of the trapezoidal panels unfolded. (Adapted by Ethan Thurmond from Boland et al. 2022)

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.

STS Topic

The Middle East and Northern Africa are home to the earliest developed regions in the world home to immense cultures and beauties. However, these countries face a major issue, an ever-increasing lack of water. This issue has large impacts on the populations in these areas which also spread to the rest of the world. Climate change and population growth is the major factor causing issues such as longer droughts, more variable flooding, increased probability of desertification, and lower water quality (Sowers et al., 2011). The poorest countries and populations will feel the greatest costs of climate change, and this is only the beginning. The oil-exporting states have already exceeded their freshwater resources many years ago and rely on other techniques such as groundwater and desalination. About 780 million people around the world do not have access to clean drinking water and that becomes very clear in areas such as the middle east in Africa (Salaam-Blyther, n.d.). With these areas constantly coping with polluted water or only have access in certain intervals of the day. The lack of basic needs can lead to violence and psychological stress, which is already seen there and in different parts of the world. Water scarcity can lead to mental illnesses such as depression, anxiety, solution isolation, etc. (Ženko & Menga, 2019). Population increases currently on the rise every year was predicted back in 2000 to reach 651 million people in 2030 (Sowers et al., 2011). Currently in 2022 estimates are 472 million people and trends show no sign of any sort of plateau coming soon (*Population, Total - Middle East & North Africa | Data*, n.d.). While, nothing can stop the effects

of climate change and population rise, technologies such as hydroponics can offer support to help these populations until climate change can be addressed properly.

There is a lot of evidence on how climate change is affecting the region, but there is not an analysis of the connection of implantation of a new farming technology and how the effects could transpire. However, there is a lot of research of how politics have affected the countries for better or for worse. I will write an analysis of how implementing hydroponics in North Africa and the Middle East will can offer a solution to the farming crisis and the effects it may possibly leave on the country.

It is well known that these regions have had internal conflicts over resources leading to war and stress. The lack of water resources has caused these issues to make these problems worse. The politics of water have contributed greatly to the instability of the region which has led to the distrust in countries own governments and neighboring countries. Tensions have only been increasing in recent years, and without a change life will becoming increasing challenging for the individuals in this region along with the ripple effect it will have across the world. While identity plays a large part of the conflict in this North Africa and the Middle East, economic motivations for wars are the key to understanding what is truly happening (*Conflict Economies in the Middle East and North Africa*, 2019). Hydroponics can offer a solution but an analysis of how this technology may affect this region will provide insight on if this technology will cause instability or provide something the people in this region can look forward too.

Methodologies

Research Question: How does the lack of access to clean water resources affect the Middle East and North Africa and how will the implementation of hydroponics offer a solution.

To answer this research question, I will be using the Technological Fix STS theory and Historical Case study methodologies. To begin, I will give a background on the Middle East and Northern Africa's water crisis and how these effects have affected the region socially, politically, and economically. A technological fix is an attempt to is an attempt to use engineering or technology to solve a problem. Newberry's technological fix utilizes an analysis of the technology and if it indeed solves the problem or instead offers a temporary solution that does not solve the actual problem (*Technological Fix | Encyclopedia.Com*, n.d.). Hydroponics may end up not being the correct solution for these regions and this paper will hopefully provide some insight on that. The historical case studies of technologies being implement will allow me to see if hydroponics will follow the same pattern of worsening economic growth or will allow a new age of prosperity.

Conclusion

This paper covers an investigation of how hydroponics can be implemented in SIDS to provide the countries stability during natural disasters. The team will create a floating farm which will house the crops during storms and allow farmers to continue farming after the disaster passes. The team must create a structure that is structurally sound, efficient, and cheap for the people in SIDS. The result of this project will provide a structure ready to enter the market for communities in SIDS.

On a similar note of hydroponics, this paper explores the potential effects of implementing hydroponics in North Africa and the Middle East. Specifically, by exploring politics of water resources scarcity and the effects that has had on these regions. Currently these

regions face poverty, famine, economic instability and more. This research will provide insight on if hydroponics should be implemented in these regions.

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