Undergraduate Thesis Prospectus

A Floating Farm for Hydroponic Crop Cultivation

(technical research project in Systems Engineering)

California Water Shortages: The Fight for Water Rights

(sociotechnical research project)

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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General Research Problem

How can the risk of global food shortages be mitigated?

According to the World Bank Group (WBG), global food shortages are on the rise (WBG, 2022). Countries around the world have seen major inflation in food prices over the past year. Climate change and territorial conflict have disrupted the trade and production of goods. Experts suspect food insecurity will only continue to rise within the next decade, exacerbating malnutrition and poverty (WBG, 2022). The United Nations (U.N.) states that agricultural systems greatly impact food production and waste, thus sustainable systems must be pursued to counter this (U.N., n.d.). Water scarcity is a growing concern since it is a key input in food production (U.N., n.d.).

A Floating Farm for Hydroponic Crop Cultivation

How can an existing hydroponic crop cultivation (HCC) system be modified to perform under certain circumstances?

My technical advisor for this capstone project is Garrick Louis from the Department of Engineering Systems and Environment. I am collaborating with Ethan Gerlach, Ethan Thurmond, Arthur Hoang, Anwar Longi, and Derek Sprincis. My group will modify a "Fold-out-Farm" that supports a hydroponic crop cultivation (HCC) system on a floating platform.

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. According to the United Nations, (U.N.), SIDS make up 1% of the global population yet 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 U.N., climate change is projected to negatively impact the four pillars of food security – availability, access, utilization, and stability – during the 21st century (U.N., 2020). 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. My capstone hopes 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 a supplementary power supply when necessary.

Caribbean SIDS are especially vulnerable to climate change due to their close connection to coastal environments. Global mean sea level is currently rising at around 3.6 mm per year (Baptiste et al., 2020). This rate only increases with higher emission scenarios with possible meters of sea level rise by 2300. This is detrimental to 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). Several nations in the Caribbean have large agriculture sectors which contribute to upwards of 20% of their total GDP. However the Food and Agriculture Organization (FAO) finds 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). 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). 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 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). My capstone will be building on the

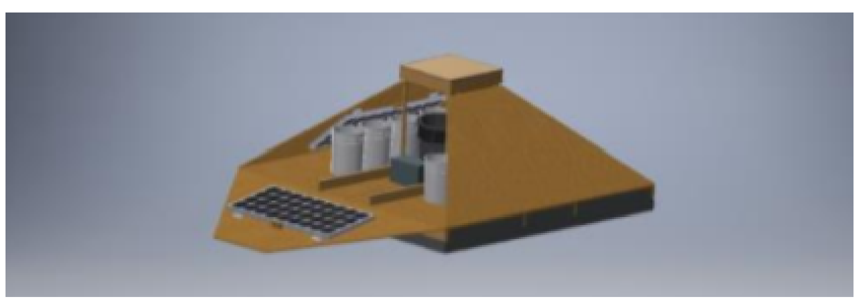

Figure 1: Floating platform AutoCAD model, partially folded: An overview of the current system depicting one of the trapezoidal panels unfolded. (Adapted by Ethan Thurmond from Boland et al. 2022)

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 will 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 by contacting stakeholders in SIDS and seeing where the demand for this product is strongest. If we develop a solution to these problems with remaining 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).

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 done during the Spring semester of 2023.

California Water Shortages: The Fight for Water Rights

How do interest groups in California compete for a greater share of water resources?

California is an agricultural superpower, however, water shortages threaten that status. According to the California Department of Food and Agriculture (CDFA), California dominates the United States' vegetable production by over 30% and fruit and nut production by 75% of total production (CDFA, n.d.). Escriva-Bou (n.d.) states that climatic and regulatory restraints have limited water access for Californian farms recently. These dry conditions have dropped the amount of water deliveries to farms by 41%, raised groundwater pumping costs for farmers by $184 million, and has caused farmers to abandon 395,000 acres to leave unplanted . Some farmers are forced to underwater their crops, which can lower yield. Overall, $1.1 billion and over 8700 jobs were lost (Escriva-Bou et al., n.d.).

Researchers have looked into social organizations amid an environmental crisis. Folke (2005) found that communities self-organize and implement management techniques to build resilience against unexpected environmental changes. Knowledge is “organized and culturally embedded” by groups as a tool for “understanding and managing periods of rapid change” (Folke, 2006). Ritchie (1995) found that non-governmental organizations (NGOs) and operational coalitions adopt many strategies to convey their messages, which can consist of media coverage or lobbying of government officials. They can advocate policies, cultivate support, cultivate enthusiasm and hope, and educate the public through their efforts. Lassiter (2015) elaborates that governmental organizations enforce environmental laws to protect the interest of the state. Policy mandates are a tool used by these groups.

Non-governmental groups in California advocate for a greater share of the limited water source for agricultural use. The California Farm Water Coalition (CFWC) states that they seek to “increase public awareness of agriculture’s use of water and provide a common, unifying voice for agricultural water users” (CFWC, n.d.). The coalition is committed to educating the masses about the role of water in food production and the policies in place that may restrict this. The CFWC (2021) critiques the State Water Resources Control Board (SWRCB) for “eliminating water supplies for thousands of family farms throughout the Central Valley”. California Water Alliance (CalWA) states that they hope to “keep our government accountable to current and future sustainable water policies”, specifically by “advocating for an increased water supply benefiting families, cities, businesses, farmers and the environment" (CalWa, 2021). CalWa is working to educate policymakers on why farmers need a reliable water supply and has developed a "wide range of solutions to create a new approach to managing California's water" (CalWa, 2021). The Agricultural Council of California (ACC) states they seek to advocate for "more than 15,000 farmers across California" to keep them "productive and competitive" (ACC, n.d.). The ACC urges policymakers to address water and drought budget priorities by offering recommendations (ACC, 2022).

Two governmental organizations limit the amount of water available for agriculture. Groundwater Sustainability Agencies (GSA) is a series of local agencies that aims to manage groundwater basins by "measuring and limiting groundwater extractions, imposing fees for groundwater management, and enforcing the terms of a groundwater sustainability plan" (GSA, 2020). SWRCB states its mission is to "preserve, enhance and restore the quality of California's water resources and drinking water for the protection of the environment, public health, and all beneficial uses" (SWRCB, 2021). SWRCB has issued curtailments on water rights holders to "preserve stored water to protect drinking water supplies, prevent salinity intrusion and minimize impacts to fisheries and the environment" (SWRCB, 2021). According to SWRCB, "a water right gives the holder the legal right to use water for beneficial purposes such as fishing, swimming, farming, and more" therefore, "when water supplies are limited, like during drought, the State Water Board can restrict water rights" (SWRCB, n.d.).

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