A Systems Analysis of Hydroponic Crop Cultivation for Food Security and Nutrition

(Technical Paper)

Hydroponics in Humanitarian Aid: A Review

(STS Paper)

A Thesis Prospectus Submitted to the

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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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Thesis Prospectus

Introduction

My Capstone (technical) project is focused on the uses of hydroponics in humanitarian aid, specifically hurricane disaster relief in small island developing states. The project is a continuation of previous research conducted by the same advisor, and therefore builds off of the work of the past three Capstone groups involved in the project. The current iteration of the technical project is twofold, a civil engineering project and a systems engineering analysis. The civil engineering project is to build a hydroponic crop cultivation system on a floating platform that can withstand flooding and high winds caused by natural disasters such as hurricanes or rising sea levels. The systems engineering analysis is to produce two evidence based system evaluations, one on which possible humanitarian application of hydroponics should be chosen, and the other on which agricultural method should be developed, considering the work of previous iterations of the project.

My research question in relation to said technical project is to expand from the focus of the technical project on small island developing states and investigate other possible humanitarian applications of hydroponic crop cultivation. The technical project primarily focuses on island and coastal communities, as it is an extension of previous projects and partnerships in that field of study. By focusing on this one aspect of humanitarian aid, other aspects receive less attention despite efforts to expand the theoretical scope of the technical project. However, the increasing impact of climate change brings challenges to agricultural practices across the globe such as worsening natural disasters, rising sea levels, and inconsistent weather patterns, though those challenges may vary depending on location and local climate. Rising climate change impacts in agriculture compounded with a rapidly growing global population will only increase

issues of food security, especially as traditional methods of food production are further disrupted. Hydroponic crop cultivation could be used as a way to produce greater yields in shorter amounts of time, while also using less resources and being able to grow in more accessible locations. In concert with my technical project, investigating other possible humanitarian applications of hydroponic crop cultivation provides groundwork for new avenues of research and design. This year's technical project may be focusing on one specific use case, but future groups may choose to broaden their project scope into new situations and applications of hydroponics in humanitarian aid.

Technical Project

My technical project will assess the possible uses of hydroponics and other agricultural methods in humanitarian aid situations. Additionally, we will design and build a hydroponic crop cultivation system on a floating platform for areas experiencing natural disasters such as hurricanes and rising sea levels with periodic flooding and high winds. We will be analysing possible agricultural methods such as a floating hydroponic crop cultivation system, traditional soil-based farming, and aquaponics by various metrics including ease of use, cost, and the ability to survive extreme weather events in order to select the best method for our focus on humanitarian aid for island and coastal communities experiencing periodic flooding. The chosen method based on previous iterations of the technical project is a hydroponic crop cultivation system on a floating platform. If our analysis does not support this as the best decision, we must provide justification as to why the project went in that direction regardless of the results of the analysis.

We will also be researching and analyzing the potential use of hydroponics in other humanitarian aid situations, such as in refugee camps or food deserts. For the physical design, we

will be focusing on humanitarian aid in island and coastal communities facing hurricane seasons worsened by climate change. As the current project is an extension of previous work in that field, we will honor the connections built and research done by those previous technical projects. The current focus on a hydroponic crop cultivation system on a floating platform is also an extension of previous research into the self-sustainability and durability of the system. Previous versions were able to run off of rainwater harvesting and could be broken down to be moved if a storm came. This year we are asking if we can keep most of the previous design accomplishments while making the system able to survive flooding and high winds unaided.

STS Methodology

For this paper, I plan to conduct a review and synthesis of existing research in hydroponics and humanitarian aid, with a particular focus on the intersection of those two fields of study. I will search out foundational texts in these fields, examining those explicitly in conversation with said works as well as any stakeholders to projects who are not included in the research. As hydroponics is a newer field of research, there may not be a depth of information existing, especially in the niche cross-section of hydroponics and humanitarian aid which I am focusing upon. Should I discover primary sources related to the use of hydroponics in humanitarian aid, outside of controlled greenhouse environments which most hydroponics research seems to focus on, my research will then primarily focus on that specific use of hydroponics in humanitarian aid as a practical example of my research question. Therefore, it may be useful to note areas not currently included in research in the same manner as one investigates stakeholders who are left out of formal reports and why.

Additionally, I will interview University of Virginia organizations focused on humanitarian aid to gauge their thoughts on the use of hydroponics in humanitarian aid such as

refugee camps or food deserts. Leveraging their expertise in humanitarian aid causes and evaluating their knowledge of and trust in hydroponics could lead to new avenues of research not previously considered. As my background is so solidly placed in science, engineering, and technology, involving others with more diverse thought processes could lead to new understandings or sources I had not previously considered.

Key Texts

Francesco Orsini, Remi Kahane, Remi Nono-Womdim, Giorgio Gianquinto. Urban agriculture in the developing world: a review. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA, 2013, 33 (4), pp.695-720. ff10.1007/s13593-013-0143-zff. ffhal-01201393f https://hal.archives-ouvertes.fr/hal-01201393/file/13593_2013_Article_143.pdf

This article is a review of various urban agriculture efforts in the developing world, including hydroponics, and how they support food security efforts in those areas. Growing food locally in urban areas is key to increasing food security in said areas, especially as the global urban population continues to grow. Concerning food security, urban agriculture significantly impacts the food security and health conditions of poorer populations, as they are most directly impacted by a lack of reliable access to fresh and affordable fruits and vegetables. The sustainability of hydroponics as a method of urban agriculture has been reported in several locations and situations, with encouraging results. Hydroponic crop cultivation systems used in urban areas of Peru and Brazil returned their initial overhead investments in under one year. Additionally, hydroponic systems have been noted to have about five times lower mean daily water requirements per square meter than conventional soil-grown crops due to water recirculation. When combined with multiple sources reporting nearly twice the yield grown with hydroponics compared to conventional soil-grown crops, hydroponics farmers get nearly twice

the crops for five times less water required. However, the success of these hydroponic crop cultivation systems depends on the reliable accessibility of whatever nutrient solution is being used, as most consumers purchase this necessity weekly rather than in bulk. Impacts on the supply chain of the nutrient system would therefore have ripple effects throughout the hydroponic farming communities. This article predicts that in the near future, urban horticulture will be driven by consumers in both consumption and policy decisions, as local leaders realize that both the producers and consumers of urban horticulture are their electorate. The arguments listed here are important to my paper as examples of hydroponic crop cultivation in contexts other than commercial use.

Treftz, C. and Omaye, S.T. (2016), "Hydroponics: potential for augmenting sustainable food production in non-arable regions", *Nutrition & Food Science*, Vol. 46 No. 5, pp. 672-684. https://doi.org/10.1108/NFS-10-2015-0118

This article is a literature review providing a foundation of knowledge about hydroponics in food security roles. It briefly touches on the sustainability issues with traditional farming (overuse of soil exhausting nutrients, the amount of land needed, and harmful pesticides), and moves to a comparison between hydroponic crop cultivation and traditional farming methods, complete with a scientific justification for the validity of the comparison. The benefits of hydroponics include less labor-intensive work, lower water consumption, the ability to grow multiple crops per year, and growing food directly in communities for the communities producing the crops. Negatives of hydroponics include high overhead costs, a dependency on a constant source of electricity, and the vulnerability to plant disease introduced by a closed system. The article provided a very detailed synthesis of a multitude of studies on the nutritional value of hydroponically grown crops, listing their findings and the shortcomings of those

findings. The author explained the difficulties in directly comparing the quantitative findings of different studies, which is important for review and synthesis papers to clearly state so that their findings and synthesis can be understood in a larger, more comparative contrast. The author concludes by stating that more research is needed into this growing field of study, but once that research progresses hydroponics could play a significant role in providing food to non-arable environments.

Irfanullah, Haseeb Md., et al. "Introduction of Floating Gardening in the North-Eastern Wetlands of Bangladesh for Nutritional Security and Sustainable Livelihood." Renewable Agriculture and Food Systems, vol. 23, no. 2, 2008, pp. 89–96., https://doi.org/10.1017/s1742170507002074.

In this study, the research group introduced a traditional southern Bangladesh soilless farming method to the north-eastern wetlands of Bangladesh, creating a feasible alternative to soil-grown crops. The study touched upon the household level food security and poverty alleviation effects of introducing floating gardens to northeastern areas heavily impacted by monsoon seasons. The author(s) presented a fairly concise outline of what happened with the project outcomes and why, with quantitative figures where appropriate. They describe a significant positive impact on social dynamics and the perception of the project, as well as an increase in food availability at the household level. Limitations of the project included variation in the time and effort needed to create the floating platforms. They mention a possible extension of the project to include other areas in Asia and Africa impacted by invasive water hyacinth, a key component of the platform structure. Unfortunately, the most impactful reasons why this source is important to my project are negative. The views and opinions of the actual villagers this study was purporting to help are not presented anywhere in the paper, giving the work the impression that researchers were swanning in with a question they wanted to answer, regardless

of whether the most important stakeholders — the villagers themselves — would benefit from their actions. Additionally, the paper is written entirely in the passive voice, which works for a controlled laboratory experiment but not a study that is equally as anthropological as it is quantitative. In this respect, this article is more an example of what I do not want to do.

References

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