Hydroponics in Humanitarian Aid: A Review

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring, 2022

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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I. Introduction

Climate change, armed conflict and internal displacement, rural-to-urban migration, global economic shocks, and declining agricultural productivity increasingly threaten global food security and nutrition (GFSN). This problem receives seemingly little attention in the United States. The resulting food insecurity is distributed unevenly across the globe and across different geographical areas and socio-economic groups within countries. Globally, coastal communities and Small Island Developing States (SIDS) are most at risk (United Nations, n.d. b). Agricultural systems in these areas have a high level of exposure to climate risks including extreme weather and sea level rise (Schnitter, et al). The populations that are most vulnerable to the risk of food insecurity are lower-income, indigenous, rural, ethnic, and religious minority groups, as well as women and children (United Nations, n.d. a). Hydroponic Crop Cultivation (HCC) is one of several interventions that can reduce the threat to GFSN.

Hydroponic crop cultivation is a method of farming in which plants are grown in a nutrient-rich solution instead of soil, which decreases the amount of water used by up to 90% and significantly increases the yield per area (Benefits of Hydroponics, 2021). HCC comes in many forms and project scales, from private gardens to corporate businesses such as Babylon Micro-Farms, which provides hydroponically grown crops to hotel restaurants and large buildings such as university dining halls (Babylon Micro-Farms, 2022). Hydroponic crop cultivation systems have already been implemented in several humanitarian aid crises, including the so-called “Gaza Camp” long-term refugee camp in Jordan and food deserts in the United States (Luck, 2020, Katkin, 2012). No two crises are similar enough that the same solution will work optimally in both cases, especially across different categories of humanitarian crises. A system designed to counteract the lasting effects of hurricane damage on local nutrition rates in small island developing states will not work optimally in a long-term refugee camp in Algeria. The best hydroponic solutions – and project solutions in general – consider the specific needs, backgrounds, and opinions of end users throughout the design process (Porges, 2020; Greening the Camps, 2017).

II. Methods

For this paper, I conducted a review of existing literature on both hydroponic crop cultivation techniques and humanitarian aid crises and their responses. I sourced foundational texts in those fields, and searched for sources regarding either topic in unfamiliar fields (such as psychology journals) when necessary. For each source, I examined their findings and stakeholders to better understand the source's claims so that I might accurately represent the source in my own work. I emphasized primary sources, especially those describing the overlap of hydroponics and humanitarian aid, as I feared the combination would be too niche to have much prior literature at all. I noted subject areas not included in research or in the final reported results, including examining which stakeholders were left out of a study's formal report.

My research in science, technology, engineering, and math (STEM) fields focused on the technical aspects of hydroponics, its feasibility and capabilities. I sought to answer how HCC systems work in humanitarian aid settings, as well as where HCC is considered appropriate or not for implementation. I also researched an explanation for why (or why not) hydroponic crop cultivation is better than traditional land-based farming, and in what ways. I theorized that the people involved on an individual level would be left out of STEM papers, since STEM academia values the outsider observer method of reporting in literature, and sought to discover whether my theory was valid.

I prioritized reviewing humanities and social sciences sources alongside STEM research, both to account for my own background and to better understand the entirety of the hydroponics in humanitarian aid niche I chose to research. I acknowledge that my own background as an engineer by training lends me towards certain ways of thinking that align more closely with STEM scientific research than a truly balanced knowledge base. Therefore, I chose to prioritize educating myself in unfamiliar fields such as anthropology and sociology in pursuit of a more holistic viewpoint. For this paper, my research in social sciences fields focused on social and cultural factors behind the success or failure of humanitarian aid solutions. I sought to answer why a solution thrives or fails in a specific scenario, who exactly the individual people underrepresented in STEM research in hydroponic crop cultivation are, and whether technical details are left out of humanities papers in the same way that people are left out of STEM papers. I leaned heavily on humanities and social sciences sources, since leaving out the people who are actively impacted by humanitarian crises feels morally wrong when one is attempting to provide a fitting humanitarian aid solution to their problem.

III. Results & Analysis

A. STEM Overview

HCC is a viable method of alternative food production to alleviate instability in GFSN, and is more efficient than traditional land-based crop cultivation in several ways. HCC systems used in urban areas of Peru and Brazil returned initial overhead investments in under a year, proving the cost effectiveness of hydroponics as a method of crop cultivation (Orsini et al, 2013).

Orisini et al state that multiple of their sources reported nearly twice the yield grown and five times lower daily water requirements with hydroponics compared to conventional soil-based methods (Orsini et al, 2013). Additionally, hydroponic systems have significantly lower land requirements than conventional soil-based agricultural systems, and can be designed to minimize the already low amounts of land required by stacking trays of plants and other methods (Benefits of Hydroponics, 2021). Overall, hydroponic crop cultivation systems are less labor intensive, use less water, can grow multiple crops per year, and allow communities to directly grow their own food which increases material wealth, nutrition rates, and self-sufficiency (Treftz and Omaye, 2016).

B. Sociological Impacts

Hydroponic crop cultivation systems require fewer resources compared to traditional farming methods, enabling more people to use HCC in a wider variety of applications than traditional land-based agriculture. I discovered a variety of humanitarian applications of hydroponics in existing research when I broadened my scope beyond STEM sources. Incorporating HCC systems in refugee camps and underprivileged communities such as food deserts increases self-reliance and resiliency on both an individual and community level (Porges, 2020; Luck, 2020). Growing your own food hydroponically provides you with a source of micronutrients that would otherwise be costly to procure, whether due to lack of availability or high prices. HCC systems can also be used to grow crops for market, creating an internal source of income not dependent on work availability or seasonality. Additionally, for displaced populations with a cultural heritage of agriculture, implementing HCC systems has the added social benefits of connecting back to that heritage, positively impacting mental health (Luck, 2020). However, this cultural callback created by implementing HCC systems only works as long as the culture in question has a history of agriculture. Without connection to an agricultural or sedentary heritage, HCC systems do not create those social and mental health benefits, and may not be accepted at all (Porges, 2020).

HCC systems can also increase self-sufficiency in women, particularly in countries with gendered land-ownership laws. HCC units in homes fall under the category of domestic labor, which is often traditionally done by women and children. With its lower land, water, and labor requirements, HCC provides farming capabilities that work around local land ownership laws. As a crop cultivation system that does not require excessive land ownership, HCC gives vulnerable populations, such as refugees or women, a readily available income source within the home, thereby increasing their self-sufficiency and personal nutrition efforts (Hovorka, 2005; Greening the Camps, 2017).

Hydroponic crop cultivation requires regulations and policies surrounding its usage from many levels of government to become more widespread or culturally accepted outside of its current niche in academia. However, the governmental support needs of various HCC systems differ drastically with the scale of the project and the level of government in question. Private gardens for kitchen herbs and city-wide initiatives to green urban spaces through rooftop HCC gardens have wildly different needs and require different legislation or regulation efforts (DiDomenica and Gordon, 2016). The kitchen garden may only require laws allowing HCC systems to be purchased or created in the gardener's community. The city-wide initiative, while potentially having a much larger impact on food security or energy efficiency in the broader community, would require regulation to match its larger scale. Many layers of policy, regulations, and government levels must be managed to more commonly implement HCC outside of its current niche.

C. Blindspots and Overlap

I noticed overlapping blind spots across STEM and social science fields of study, which interact in interesting ways. In STEM academia, the people involved on either end of a research project are left out of any final reporting of results, be it a paper or a presentation. In scientific writing, particularly STEM fields, it is seen as more objective to write only about the methods, data, and results of a research study without any mention of the researchers' or participants' feelings or opinions. Authors are recommended to remove all personal opinion from their writing, as if the paper was written by an outside observer about purely objective data. This format works well with chemical experiments and other more quantitative research, but lacks a certain depth of impact when reporting interpersonal interactions. Haseeb Md. Irfanullah and co-authors conducted a study on implementing traditional floating farms (a form of hydroponics constructed out of beds of water hyacinth) native to southeastern Bangladesh in northern parts of the country, to combat the effects of rising sea levels and worsening weather patterns on crop cultivation. The paper did not include villagers' opinions, implying researchers implemented a solution regardless of whether the most important stakeholders would benefit (Irfanullah et al, 2008). Writing in the passive voice creates distance between author(s) and results, and between raw numbers and the people behind the data. Distance lessens the importance of how personal opinions and preferences impact the success of HCC implementation in humanitarian aid applications, suggesting that a solution can be implemented in all similar situations without considering the context of any specific crisis.

In addition to blind spots within STEM, works that could expose those blind spots are written in different formats than STEM academic styles. An unfamiliar paper structure, such as an anthropology paper's format, can be difficult to understand or fully comprehend the impact of the paper's findings by scholars more accustomed to the STEM format. This difficulty is not so large as to be impossible to understand, simply more challenging due to a STEM academic's lack of familiarity with a social scientist's preferred writing style – like listening to someone speaking with a different accent. Matthew Porges describes a case where anthropological perspectives were not properly considered when designing an HCC system aimed to increase self-sufficiency in Sahrawi refugee camps near Tindouf, Algeria (Porges, 2020). Regardless of the success of similar systems in Jordan, the population of the Tindouf camps came from largely nomadic backgrounds and, while they had experience in animal pastoralism, had no attachment to or cultural background of growing their own crops through any method. The solution developed — a trough-based hydroponics system — did not align with the end users' lives and desires, and was thus discarded. Designers and stakeholders could have discovered this misalignment in goals earlier in the project if they had considered anthropological sources or user input earlier in the design process than implementation. Writing humanities findings in a more understandable format for STEM researchers when potentially working in concert could be a workable compromise between the need for a different format to best describe humanities perspectives and said format's comprehensibility to a wider audience.

The overlapping blindspots in STEM and humanities fields create miscommunication and missed opportunities in both hydroponics and effective humanitarian aid. Aid relief groups may overlook the potential of hydroponics in other applications than those currently in use, such as food deserts and refugee camps. People without a scientific background may misunderstand the science behind HCC and how to correctly apply hydroponics to a humanitarian aid problem, as the best solutions are crafted to fit the needs of a specific situation rather than having one "best" solution that is forced to work in all applications. Because of this miscommunication, designers could overlook new fields of study or directions to develop hydroponics as a field. New opportunities bring new perspectives and new requirements, driving the science to innovate in order to adequately adapt to the new problem. Without that drive to improve and adapt, hydroponics as a science may not reach its full potential.

Additionally, academic elitism is present in both STEM and social sciences sources in the form of jargon and highly specific paper structure, as previously stated. This elitism greatly contributes to miscommunication between disciplines, as well as between hydroponics and humanitarian aid. Removing elitism from academic writing, regardless of field, increases the accessibility and widespread impact of a paper outside of the author's specific field of study, making their findings more culturally relevant to a broader audience.

Hydroponics is most often seen at the academic level, where more "out-there" approaches are accepted and funded that might not be feasible in the agricultural industry (Besthorn, 2013). While a viable alternative to alleviate GFSN, HCC currently does not have the level of societal impact or supporting policy necessary to successfully compete with the traditional agricultural industry. Academic successes do not compete against industry standards, particularly with regards to their budget or financial bottom line. Continuously missing opportunities for larger-scale humanitarian aid applications due to miscommunication decreases the likelihood that HCC will cross out of academic curiosity into the wider agricultural industry.

Introducing new perspectives into the design process can strengthen designs by exposing weaknesses not visible from other angles. Including different and more diverse viewpoints cover a larger range of perspectives, ensuring that the final solution works on multiple aspects. A diverse group is more likely to expose weaknesses in designs, simply by examining the process from an angle that you as the designer may not see. Additionally, questions about whether the design meets end users' need or is truly viable in a certain humanitarian aid situation are best addressed by including end users in the design process, whether through simple interviews or full participatory design (Porges, Greening the Camps).

Combining STEM and social science fields can cover the blindspots of either field, introducing technical details into sociological perspectives and reminding STEM perspectives of the individual people behind the data of their research study. However, doing so can also create new blindspots that both groups may miss. A common flaw in cross-disciplinary initiatives is that one group may not fully value the contributions of the other, which can cause issues when the group needs to combine insights. A study designing a medical device for patient information included both computer scientists and anthropologists on the project team (Forsythe, 1996). However, the computer scientists chose not to wait for the anthropologists to conclude their research on what the people involved (patients, doctors, nurses, etc) needed from the medical device for it to appropriately solve their problems regarding informing patients of their diagnoses. They began designing the software in tandem with the anthropologists' research, telling them to incorporate their insights later. However, due to the coders' lack of awareness of their own blindspots, the project had difficulties combining previously-written code with the anthropologists' findings, leading to a subpar final project that did not solve its initial problem. User centered design requires continuous user involvement from the beginning of a project to the final solution to produce an end solution that best fits the situation and the users in question.

IV. Discussion

Solutions designed for one humanitarian aid situation may not work in another, similar situation. The best fitting and most impactful HCC solutions are those tailored to the specific needs of the humanitarian aid crisis the solution will be implemented in, proved when comparing the results of implementing HCC systems as reported in Porges and Greening the Camps (Porges, 2020; Greening the Camps, 2017). Designers and engineers should work with end users from each humanitarian aid situation to develop solutions specific to the intricacies of particular cases. The local populations of a humanitarian aid crisis are most affected by any solution implemented – particularly solutions like HCC, which they will have to work to maintain. Involving them from the start of a project ensures the solution created is applicable to the situation in question.

STEM and social sciences both examine the intersection of HCC and humanitarian aid from different perspectives and with different priorities. Each field has strengths and weaknesses, some of which can be counteracted by incorporating the other field such as incorporating social sciences into STEM research to better include opinions of the people involved. Better communication between social sciences and STEM research promotes understanding and respect across disciplines, creating more opportunities and leading to better designs and designers. Removing elitism from academic writing increases accessibility outside of academia as well as across scientific disciplines, further increasing opportunities for development of hydroponics as a field of study.

Including the people directly impacted by a humanitarian aid crisis improves both solution quality and end user engagement with the created solutions, as shown effectively in Greening the Camps and poorly in Porges (Greening the Camps, 2017; Porges, 2020). The two studies both attempted to implement HCC solutions in different refugee camps. The study that incorporated end users and understood their cultural background in agriculture, Greening the Camps, created the more effective solution. Incorporating social sciences into STEM research and development ensures end users, the people most directly affected by a solution, are not forgotten or omitted from the process.

Disaster relief needs develop rapidly, without the necessary time for discussion required for user-centered design approaches. Communities and humanitarian aid providers must understand that some crises require immediate solutions, while acknowledging that prioritizing speed in a solution may lower its effectiveness and best fit to a community's needs. Communities can prepare for known disaster risks in advance, and designers can develop solutions to known problems without an immediate crisis at hand. Hurricane season is always a threat to small island developing states in the Caribbean, so HCC solutions can be developed to fit the situation without requiring the immediate aftermath of any specific hurricane. The role of hydroponic crop cultivation in humanitarian aid crises is one of long-term solutions intended to alleviate pressure on GFSN and not as disaster relief sent in the immediate aftermath of a crisis.

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