How the Implementation of Hydroponic Farms Affects Local Communities

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Ethan Thurmond

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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

Advisor

Pedro A. P. Francisco, Department of Engineering and Society

Introduction:

In this research paper, 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.

Currently many regions around the world use conventional farming methods, which requires nutrient dense soil and access to water, sunlight, and the other facets of traditional farming methods such as fertilizer and seeds when needed (Hydroponic Way, 2023). Unfortunately there is a significant number of these areas that have serious problems maintaining traditional farms due to reasons such as arid environments that have dry soil that lacks nutrients or areas that constantly flood which destroys the local farms, hence the case in certain areas in the Caribbean. Furthermore, some regions of the world completely lack the ability to farm using conventional farming methods due to the urban landscape of the community (Hydroponic Way, 2023). In areas such as these the implementation of hydroponic farming methods could be a saving grace for many of the local farmers and in some cases the entire local community.

The topic of how hydroponic farms can help the surrounding communities is tightly coupled with the technical portion of my capstone project, building a robust hydroponic farming system to be deployed in communities in the Caribbean to be able to withstand floods and category 3 hurricanes.. Therefore, throughout my research paper, examples and comparisons to the technical aspect of my project will be made in order to help show the effectiveness of hydroponic farming systems and techniques.

Research Question:

The question that I have chosen to answer for this research paper is “How does the implementation of hydroponic farms affect and aid local communities?”. The evidence collection methods going into this research question is mainly literature review. I chose this evidence collection method because there are many well written and reliable sources that have previously collected data from experiments that allows me to gain information without having to do the experiments myself. My data analysis methods will mostly be using content analysis and case comparison, creating or reviewing statistics from the evidence and data collected in my research. I chose this method because it is a good way to use the data and evidence to compare the performance of conventional and hydroponic farming methods. The STS framework that I chose to use for this research paper is Social Construction of Technology (SCOT). I chose this framework because I believe it adequately depicts the way both the hydroponic farming technology affects the social communities surrounding it, and how the humans and culture in these communities have an influence on the hydroponic farming technology.

Background and Significance:

Although hydroponic farming techniques are rather recent in being seriously implemented in some regions of the world, the idea behind hydroponic farming has been around since the 1920’s. In 1929 the term hydroponics was coined by Dr. Gericke, who developed hydroponic farming from a research and laboratory technique to a commercial farming technique. Examples of hydroponic farming techniques being used throughout history include the farming of fresh foods by United States Army troops in the war in the Pacific during World War II (Dunn et al., 2017).

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. Lacking nutrient dense soil does not only refer to areas that are arid and naturally lack the foundation for traditional farming to take place, but also refers to areas that are industrialized and have most of the natural soil covered in urban landscape. Hydroponic farming can also be useful to allow farming to take place in such urban environments. 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.

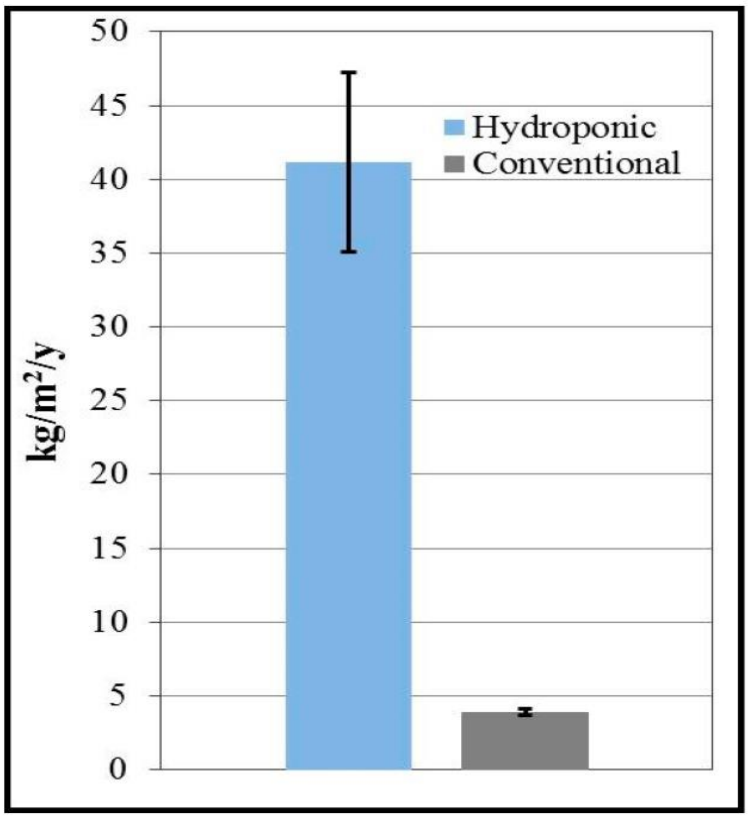
Results and discussion (evidence):

Crop yield:

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 1 on page 4 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 1
Hydroponic vs. conventional lettuce yield



Note: 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).

There are many factors that contribute to higher crop yield for hydroponic farming methods. As previously mentioned, hydroponics are more efficient than conventional farming methods in terms of how many crops can be produced in the same amount of surface area on a plot of land. However the ability to farm using vertical techniques and produce crops year-round are other reasons why hydroponic farming methods have higher crop yields than conventional farming methods. Due to the fact that a hydroponic farm can be kept indoors or in a greenhouse, the environment in which the farm is placed can be controlled therefore allowing the farmer to produce crops year-round.

The ability to be kept indoors and use vertical farming techniques is a major factor of why hydroponics can be very beneficial for residents of urban areas that need to use farming to help create revenue or feed themselves and their families. Therefore not only can hydroponic farms produce more crops in the same area as conventional farms, but hydroponics have a wider variety of locations that they can be implemented in than conventional farms, potentially allowing more people to have access to nutritious food. This leads to the next topic to be discussed, malnutrition.

Malnutrition:

Malnutrition around the world is still a big problem in developing countries. As it can be seen in Figure 2 below, a study done on children in Pakistan showed that almost a quarter of the children both in rural and urban areas were suffering from being severely underweight. Although there are many factors that could contribute to this such as poverty or lack of access to adequate amounts of nutritious food, the overarching reason for these children being underweight and in some cases wasted or stunted is being malnourished (Arif et al., 2014, pp. 103-105).

Figure 2
Table of child nutrition status by region

Child Nutrition Status (Moderate/Severe) by Region, 2010

	% Underweight			%Stunted			%Wasted		
Nutritional Status of Children	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Normal	56.9	57.7	56.7	31.2	32.6	30.7	61.8	61.9	61.8
Moderate	15.7	15.0	15.9	20.2	23.2	19.2	8.9	9.4	8.7
Severe	23.7	23.1	23.9	43.7	38.9	45.4	9.0	10.5	8.5
Over Weight/Height	3.7	4.2	3.5	4.9	5.3	4.8	20.3	18.2	21.0
Total	100	100	100	100	100	100	100	100	100

Note: table shows percentages of children that are underweight, stunted, and wasted in ranges of malnutrition from normal to severe (Arif et al., 2014).

In relation to having adequate access to nutritious food and crop yield, more crops means more food. In many of the areas that have trouble with conventional farming methods there are many cases of malnutrition in the families of the local communities. Hydroponic farming can be

a form of urban agriculture, which is said to produce on average about 15 to 20 percent of all food production in the world (Koscica, 2014, pp. 177-178).

Other studies on the effects of hydroponics and urban agriculture in general concluded that among the households in the study, families were able to produce 20 to 60 percent of their own food supplies using urban agriculture methods (Amar-Klemesu et al., 2000).

Having these statistics to represent the efficiency of urban agriculture in general, it can be seen that hydroponic farming techniques are a very effective way to combat malnutrition in areas where conventional farming methods are not viable options of producing food.

According to research done by the Food and Agriculture Organization (FAO), an estimated 75% of people around the world live in urban areas. For this reason it is increasingly important that space management for farming and soilless farming techniques such as hydroponic farming be used (Barceinas-Sanchez et al., 2022). Hydroponics can utilize space management by maximizing the efficiency of the horizontal surface area that they use, but also by taking advantage of the vertical area above the farm as well. This is sometimes referred to as vertical farming (Barceinas-Sanchez et al., 2022).

It is also beneficial to mention the fact that in many cases malnutrition occurs in families with low household incomes. In reference to the STS framework of SCOT that will be discussed in the STS framework portion of this research paper, the actors involved with the design of the hydroponic technology must take this into consideration and balance an efficient system with an affordable product as well. This is an example of how society can affect the production of technology, as well as how it may be used.

Economic benefit

Not only could hydroponic farming help local farmers and their families by supplying them with their own food and allowing them to stay healthy, but hydroponic farming methods can also help local farming families financially.

There are a number of ways that hydroponic farming can improve the earnings that local farmers make off of their crop harvests. As mentioned previously, hydroponic farming methods have the potential to have higher crop yields than that of traditional farming methods. Some studies have shown that this number can be around three times as many crops or more using the same amount of surface area as conventional farming methods (Koscica, 2014, pp. 178-180). Another thing that adds to the volume of crops produced each harvest is the ability to use hydroponic farming in the vertical space above the base level farm (Barceinas-Sanchez et al., 2022). Since hydroponic farming is not only more efficient than conventional farming in terms of the same amount of square footage, but also can be used in vertical farming techniques, it is easy to see why hydroponic farming can boost the efficiency of local farming families, ultimately increasing their revenue.

Another factor of hydroponic farming that has the potential to help local farmers financially is a reduction in labor cost and physical labor efforts. Since hydroponic farming does not involve natural soil the problems that come with farming in natural soil does not apply. These problems include weeding, tiling, and other manual labor activities that are required to maintain a traditional farm. Removing this manual labor can reduce the cost of labor for farmers and increase the profitability for them as well.

As mentioned in the following section regarding the STS framework that fits with this STS research paper, technology can change the way that social communities operate. In this

case, involving increasing economic benefit of farming using hydroponics, farmers may have to adopt new habits and practices in order to effectively incorporate hydroponic farming systems into their lives. Although this is just an example of how technology affects society, the relationship between technology and society will be discussed in the following section.

Arguments connecting to the STS framework:

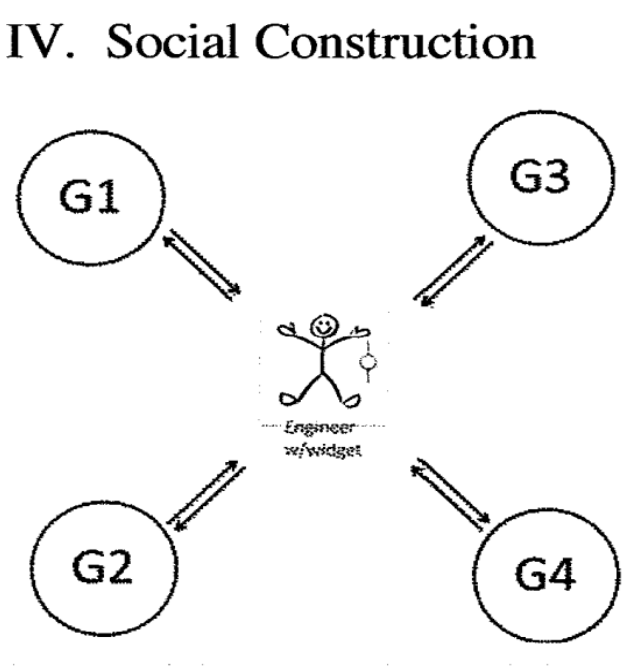
SCOT:

This research follows 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 3 on page 9 shows the specific framework mode, SCOT, that I have chosen to represent hydroponic farming 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.

Since the technical portion of my capstone project involves designing a robust hydroponic farm to help crops survive during floods and hurricanes in the Caribbean, I can give examples of how the communities in the Caribbean have affected our process of designing the system. Due to the fact that the system we are designing will in some cases be implemented in

households with low incomes, my capstone team needed to take into account the accessibility and cost of the materials and parts we use in the system so that if a low income family needs to recreate our system, they could do so with the materials and parts they can find and without financially ruining themselves.

Figure 3
Social construction STS framework model



Note: 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).

On the other hand our system, being a type of hydroponic farm, is vastly different from the conventional farming methods that these communities in the Caribbean are used to. Therefore, the implementation of our team's system will cause the local communities to adapt to the use of the new farming techniques. In these examples it can be seen that both the communities that our system will be implemented in and the system itself have influences on each other, showing that the social aspects of the world and technology have an effect on how one another progress.

With the progression and design of these hydroponic farming systems being affected by the cultures and communities in which they are intended to be implemented in, it is important for the developers and regulators of these systems to develop strong science and technology public policies, STPs, and design these systems with the well being of the people that will using these

systems being the main design objective. Having said this, if the farmers in areas that could benefit from the use of hydroponics refuse to change their habits and adapt to the new technology, then the implementation of hydroponic systems will never work. Therefore, it is both up to the developers of the system to make an affordable and effective system, and to the communities using these systems to adapt to the new technologies in order for these systems to actually produce beneficial results.

Conclusion:

The implementation of hydroponic farms is important because it allows local communities to combat malnutrition, improves farming efficiency, as well as improving the local economy, through means such as providing a way to farm in areas where the soil lacks nutrients, open up more farming jobs where there are not enough conventional farming jobs for farmers, and preserving water and soil resources by using farming techniques that do not require the use of natural soil and can be used in urban environments. As it has been discussed in this paper there are many ways that hydroponic farms can improve the lives of the families, companies, and communities that use them. Being able to farm using vertical techniques, having an increased and ultimately more efficient crop yield, and being able to farm year-round are some of the ways that hydroponic farming can help boost the availability of nutrients for the people in the communities that these farms are implemented in, as well as allow the farmers using the system to produce more revenue for themselves and their families.

Certain arguments and questions can be raised as to if hydroponic farming is such a good option, then why are these farming methods not already in use everywhere. The answer to this question lies not within the capabilities of the farming method, but within the education and

effort it takes to design hydroponic systems. First of all, in order to build even the most basic hydroponic farming unit, the farmer needs to be educated on the basics of hydroponic farming and how to build the unit correctly. Even if the farmer has access to all the materials needed to build the hydroponic unit, they may not have access to things such as the internet to allow them to learn how to correctly assemble the hydroponic unit. This is why it is crucial in today's world that project groups, such as my technical capstone project group, and other groups or companies that focus on funding and designing hydroponic farming systems help implement their designs into areas that might benefit from them. Furthermore, these groups that are well versed in hydroponics and possibly other farming methods should help educate the areas that their systems are deployed in to allow knowledge to spread about hydroponics and a wider variety of farming methods in general, so that the residents of these areas can effectively use these systems and potentially improve the designs of the systems they use.

Conventional farming methods however do not necessarily need to be gotten rid of in the areas where it is very viable. In some areas of the world there are no issues with the accessibility to nutrient dense soil and groundwater supply. However, conventional farming can be damaging to the environment if too much land is taken up for farming, for example the soil can degrade and conventional farming methods can become less feasible or too much groundwater can be used. This is why hydroponic farming methods in conjunction with conventional farming methods is a good route to take to help prevent any harm to the environment while potentially maximizing efficiency (Dunn et al., 2017). Overall it is entirely up to the farmer to decide what farming methods are best suited to their lifestyle, however with increasing research studies and data on hydroponic farming, hopefully the farmers of the world will be able to gather more knowledge on the wide range of farming methods in order to make a more educated decision that

my help improve their quality of life as well as potentially improving the quality of life of those around them.

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