Hydroponics Reasearch Paper by Wascar Soriano for Professor Appet



When was the last time you consumed good quality lettuce? Or basil? better yet when was the last time you had safe organic produce readily available in your Neighbourhood? Many individuals fiercely defend conventional agriculture (large scale industrial farming) but are often unaware that it is affected greatly by decreases in freshwater sources, arable land due to pollution, contamination, and from climate change. There is a solution that can help aide the demand for fresh produce in environments where it would be very difficult, if not impossible, to conventionally farm and that it would be immune to climate change, loss of arable land, soil contamination, and pests. That solution is hydroponics.

Hydroponics are a way of farming that does not rely on soil using substitutes such as coco coir made from coconut husks (a biproduct of the coconut industry) and sometimes saw dust (a byproduct of the lumber industry). This gives new life to what would otherwise be considered waste and repurposes it for the growth of safe, organic produce that can be grown even where conventional farming would be impossible. This is because hydroponics can be grown vertically and do not require vast amounts of land, as Hydroponic systems would be built on racks one over the other and in small places where the space can be repurposed. One notable example of this is the TeensForFoodJustice MLK JR hydroponic farm in the Neighbourhood of Lincoln Center of New York City, where the campus contains six schools and two cafeterias. In the south cafeteria of the campus, a space was repurposed alongside the south cafeteria for a hydroponics farm that grows 10,200 pounds of student grown organic hydroponic produce a year that are used to feed students in the school's cafeterias. The nearby food pantry and a free produce distribution two times per month on every first and third Thursday of the month (**TFFJ**). Hydroponic produce is also grown in a contained environment which lessens and or eliminates the risks of pests and soil-based diseases which in return eliminates the need to use pesticides which in high enough concentrations overtime can become a human health risk (**Park**,

Williams).



Furthermore, the use of hydroponics help delivers fresh produce to urban centres such as New York City where thousands of people find themselves in food deserts where fresh produce are nearly non-existent. Since hydroponics can be placed where conventional farming cannot, it aids the demand for fresh produce where needed and adjusts to rising populations of people in urban centres. Over time this increases the health of the communities by giving them better access to healthier foods that can be effectively distributed to the populations. especially because hydroponics have proven to be 1.7 to 4.3 times more land use efficient than other methods of agriculture (**Srinivasan, Yadav**). This is because they are soilless and can be grown vertically as opposed to other types of agriculture especially as the world population is set to exceed 9.1 billion by 2050 (**Srinivasan, Yadav**). With the growth of populations comes the growth of urban areas and the demand for fresh produce in such so aiding the demand in a sustainable way is a goal to prepare for the growth of populations in this ever-changing world.

My own view is that many scholars' analysis of the value of large-scale industrial farming in comparison with hydroponics is in fact an oversight of the situation. They argue good produce ONLY comes from the marriage of good sun and soil because truly delicious food can only come from the earth because since the beginning of agriculture cuisines have been developed based on the needs of the land. However, I argue Hydroponics, as stated earlier, seek to aid sustainability and production of organic produce, not the replacement of the industrial agricultural system. Hydroponics, unlike most types of conventional farming, can be managed by very little personnel: often needing 5 or even 4 people to run a farm efficiently. This makes it much more manageable to establish larger number of farms as the amount of personnel needed to run them would be much less, because with hydroponics, one can control the amount of nutrients being fed to the plants, which ensures all plants receive equal nutrients (Seungjun, Lee). An example of a hydroponic system that is nearly automatic in care is the Shallow Raft System. In this system water is constantly flowing on the reservoirs where the rafts are floating; these rafts

where the plants will float are made of foam and the only steps that are needed to be done by a person is seeding where seeds will be placed in the coco coir plug and placed in a germinator for them to sprout and transplanting where the seedlings are placed from the germinator into the rafts. The next step is harvesting where the roots are cut from the plant while still leaving the Coco coir plug attached to the plant and then the produce is ready to be given out to the populations. This becomes substantially important because "the total amount of time for most hydroponically grown produce is about 5 weeks from seed to harvest" (**TFFJ**) even though some produce such as mint can take up to six weeks from seed to harvest. lastly the rafts are removed and washed to ensure sanitation. This maintains high levels of sanitation especially as human hands are only allowed to touch surfaces of the farm with washed hands covered in plastic gloves sanitation is so important touching any surface such as cell phones, laptops, hair among others requires the discarding of those gloves and the wearing of a new pair (**TFFJ**).

After the process of harvesting Hydroponics there are roots left over all connected in a complex manner and floating on the rafts these roots can be used to make organic compost, but they can also be used as hydroponic root mats (HRMs for short). Hydroponic Root Mats are floating wastewater treatment systems where aquatic vegetation filters wastewater through their dense roots these are often supported by rafts or other floating materials. these Hydroponic Root Mats have been used for treating various types of polluted water such as polluted stormwater, domestic wastewater, agricultural effluents and even acid mine drainage (Chen, Zhongbing) this gives a second and even third life to the roots once they are taken out of the reservoir where the hydroponics are grown. This ensures that most of the items that are part of hydroponic process are reused as much as possible leaving as little waste as possible. Adding to its sustainability and therefore its environmental benefits.

During a TeensForFoodJustice produce distribution on the MLK JR Educational Campus hydroponics farm in the fall of 2024, I had the pleasure to interview a resident of the borough of the Bronx of New York City, and receiver of the free organic produce from TFFJ. She expressed: "This produce has been very helpful and beneficial for me. From all the types of lettuce Butterhead lettuce is my favourite. I also love Swiss chard because of its delicious flavour and texture, when I cook it, it becomes soft but still has a crunch to it and, sweet basil because I give it multiple uses among them, I make pesto, and I add it to juices to give them an extra kick. The TFFJ grown produce are much better, they are organic they have a crispier texture, and a better flavour: sometimes the supermarket vegetables are bitter and are not as fresh. Receiving these vegetables have greatly helped me economically because thanks to TFFJ every other week I receive these vegetables which to me are of great importance because sometimes I have not been able to buy vegetables because of my low resources but thanks to TFFJ I have been eating many more vegetables after I started receiving them and they are healthier too which has favoured my health a lot because I suffer from low bowel movements but after I started to receive and consume these vegetables I have found myself going to the bathroom more often and I have felt more motivated to eat healthier. I have also felt more energetic and in many ways happier. I would even like to advocate to city officials to give funding to these farms because it would benefit low-income people like me which would otherwise find it difficult to afford fresh produce." this gives us an insight on how big the impact of TFFJ Hydroponic farms have on the people of New York City this also reveals that we are inspiring people to advocate for food justice in this ever-changing world.

Many critics of hydroponics say hydroponics divorce food from nature because they are not grown on soil, and it concerns them because for centuries cuisines have been developed based on what the land and plants demanded (New York Times). These claims come from the belief that people don't know how soil works. However, this does not address the fact that conventional farm produce is bred to withstand shipping and transportation since, it is brought from places further away such as California and shipped to the east coast. But hydroponics are locally grown, which means the produce does not need to be bred to withstand shipping and transportation. Rather, they can be bred for nutrition, genetic diversity and flavour (New York Times). I conducted an experiment after noticing a trend between hydroponic produce and conventional agriculture. Conventional farming produce such as romaine lettuce lasted less time when stored in the refrigerator and sometimes picked up a bitter flavour. while the hydroponically farmed romaine lettuce lasted more than 2 weeks and it retained its flavour and texture. The flavour of the produce was different from the start. The hydroponic romaine lettuce had a sweeter greener flavour while the conventional farm produce had a more bland flavour this is because those lettuces that are farmed conventionally are breed and grown to withstand the transportation process unlike hydroponic produce which as stated above are grown for diversity, nutrition and flavour this trend also continues with arugula which the hydroponically grown has a spicy kick similar to mustard, Cucumbers hydroponically have a sweeter tone and different varieties of lettuce: oakleaf, red oakleaf, and butterhead all which have a crunchier crispier texture and sweeter-greener flavour. These flavours and textures are nearly non-existent in the conventional farm produce.

Most produce from conventional farms come from places further away it produces more greenhouse gasses in other words when the produce in loaded into a truck and shipped over from California those truck are producing greenhouse gasses as they travel which add to climate change (**Srinivasan, Yadav**). Hydroponics however are locally grown meaning there is no transportation that can add greenhouse gasses to the environment. Therefore, hydroponics is much healthier to the environment on the grounds that it is not producing these greenhouse gasses. But hydroponics also does not generally produce them during harvesting for this we can look at TFFJ hydroponic farms which are hand harvested meaning no machinery that can produce any type of pollution is there. This reveals that hydroponics have lower greenhouse gas emissions compared to conventional farming.

Hydroponics are grown in a contained environment away from environmental effects such as torrential rain, and Drought (**Park**, **Williams**), Which would not affect it because it does not rely on rain or conventional irrigation systems for water, meaning that water can be utilized more effectively making this vulnerable essential resource much more efficiently used by hydroponics. As many sources suggest hydroponics effectiveness come from its many strengths in the face of problems that affect the agricultural system often such as the named earlier are; climate effects such as drought. As a result, hydroponic produce harvest have been quite effective and productive even during the drought watch and warning in New York State in fall of 2024 which labels New York City (all five boroughs) and Westchester county as drought "warning" (**NYSDEP**) but hydroponic farms have still been producing the same amounts of produce which shows one of the many real-life instances where hydroponics are able to thrive where many other forms of agriculture might not. This reveals that in the case of an emergency were severe drought can risk public health and food production. Hydroponics can still provide foods to these communities without depleting the freshwater available.

Hydroponics are not intended to replace conventional agriculture: it seeks to aide sustainability by using land efficiency to a greater extent and bring a more organic approach to food production, which in the long term is safer for human consumption and management. Due to climate change we currently have fewer freshwater sources available, and we are more susceptible to drought and torrential rain and scorching heat. This is accelerated by the fact that thirty percent of the water used on conventional agriculture goes to waste (**Barbossa, Lages**), and often this water also contains fertilizers for the plants that would then sweep through the soil and contaminate underground water sources. However, hydroponic farms provide ninety percent less water usage than conventional farming, one hundred to two hundred percent greater plant diversity and density since it doesn't rely on monocultures. Twenty to thirty percent faster growth rate which allow us to grow crops from seed to harvest in five to six weeks, and ZERO toxic chemicals because these are not sprayed with any chemicals since the crops do not need it (**TFFJ**). This gives us a view of the extent that hydroponics benefits the people and the environment where not only conventional farming fails but also where monocultures do.

Hydroponics can help move away from monoculture in agriculture. A monoculture in agriculture is where the same variety is grown over and over without providing any genetic diversity which makes those plants more susceptible to disease because if one is affected the rest are affected the same applies with pest because having a monoculture means if a pest likes a crop it has a large supply of it which then leads to a thriving environment for these pest to feed and reproduce. In return this makes pest much worse as the population is larger this leads to the use of pesticides which damage the fertility of the soil and in many cases the safety of the produce being sprayed and if the concentration of pesticides on the produce is high enough it can become a health risk (**Park, Williams**). which is why hydroponics are trying to bring organic approaches because hydroponics are trying to help sustainability in the agriculture until we can make large scale agriculture sustainable and organic because overtime if we continue the way we are now most of our farmlands will be unfertile and unable to grow anything.

Of course, Many will likely disagree with the use of hydroponics on the grounds that Conventional agriculture has been around for many centuries and the large scale conventional industrial farms have been around for a little over a century and produce a lot of food But fanatics of conventional farming would certainly take issue with the argument that hydroponics should be used to grow food (New York Times). but they too often oversee that hydroponics are not going to replace but aide the production of produce and the goal for organic production and sustainability. To reiterate, hydroponics are NOT looking to replace conventional agriculture but to aid it until we can make conventional agriculture sustainable. For example, while leafy greens such as kale, lettuce, and arugula are farmed very well hydroponically, the farmlands that tend to grow this produce can focus on more hearty foods such as non-monoculture potatoes, wheats, and tubers which tend to be in higher demand especially in the Fall because of thanksgiving and early winter because of the holidays. Furthermore while tomatoes and cucumbers can also be grown hydroponically that space can be used for the growing of carrots better yet for the growth of garlic and other staple foods of the American food system along with re-inventing the Fresh-Food Supply chain because as we saw during the Covid 19 Pandemic the fresh food supply system was not as resilient as taught by most (New York Times). Which raises concerns especially as populations in urban centres grow because if we were to go through another pandemic where restrictions and social distancing were to be put in place it would not be so accessible to receive fresh food for most of the population as it was already a struggle for a lot of people during the Covid 19 Pandemic.

As countries developed their methods of farming developed along which brought innovative processes to create what we know as conventional farming and along with conventional farming. Developments were brought forward to increase crops yields and gain as much as possible from the land but as crop yields increased something was left behind that was nutritional value because as conventional farming developed by gaining as much as possible from the land it left nutritional value behind and it did not carry it through its development process which today results in high yields of produce from conventional farms that rely on fertilizers and pesticides to continues to produce theses high numbers but the nutrition is still not what is used to be it is now lower (**Barbosa, Lages**). Hydroponics on the other hand has high yields but without sacrificing any other aspect of the produce in other words hydroponics have high yields, high nutritional value, no toxic chemicals, high crop diversity, and faster growth rate. Without the use of soil, without the use of vast amounts of lands, and without the use of pesticides. This allows for faster food production using a fraction of the land and water of conventional farming (**TFFJ**) this provides the opportunity to sustainably grow large quantities of produce in urban environments. produce that is nutritious and healthy for the populations to consume enjoy and cheer.

To bring the argument to a closing circle: Hydroponics have positive goals as Hydroponics is looking to have a just food system for all because indoor growing is a solution to food scarcity as we want people to have access to fresh food but not everyone can whether it is because of availability, `freshness or affordability. We desire and work every day to ensure that the hydroponic produce that we grow is used for those who need it, for free because our job as hydroponic farmers is for people not profits, is for the future not our pockets, is for food equity and for the generations to come and for the communities to have access to healthy food which will in turn make them healthier but the fight will be long to achieve our goals but we are willing to fight and fly on to the last drop of blood because there is no greater duty than to ensure the welfare. Future and food security of our communities because we believe access to healthy food is a basic human right. Our vision is to build the capacity of food desert communities to grow and distribute fresh, nutritious, culturally appropriate, affordable, and accessible produce.

Wascar and TFFJ

CITATIONS:

TeensForFoodJustice

https://teensforfoodjustice.org/ Special thanks to Alyssa Gardner TFFJ member and Senior educator in MLK campus's TFFJ hydroponic farm.

NewYorkTimes: No Soil. No Growing Seasons. Just Add Water and Technology.

https://www.nytimes.com/2021/07/06/dining/hydroponic-farming.html

New York State Department of Environment Protection.

https://dec.ny.gov/environmental-protection/water/water-quantity/current-drought-conditions

Hydroponic root mats for wastewater: A review

(Chen, Zhongbing, et al. "Hydroponic Root Mats for Wastewater Treatment—a Review." *Environmental Science and Pollution Research International*, vol. 23, no. 16, 2016, pp. 15911–28,) <u>https://doi.org/10.1007/s11356-016-6801-3</u>.

Organic Hydroponics: A Review

(Park, Yuijn, and Kimberly A. Williams. "Organic Hydroponics: A Review." Scientia Horticulturae, vol. 324, 2024, pp. 112604-, https://doi.org/10.1016/j.scienta.2023.112604.) in this article the authors analyze how Hydroponics tend to have safer products as the Leafs and fruits are not exposed to any fertilizers and it is shown that hydroponics has higher yields as these crops have no exposure to climate change and a decrease of freshwater sources and arable land do not affect hydroponics and neither do pests and soil-borne diseases. The authors debate the benefits of using hydroponics such as lower levels of Nitrate (NO₃) which in higher concentrations is a human health risk but as hydroponics are grown on a controlled environment indoors without soil so nitrate as fertilizer is not needed. The author Kimberly A. Williams is part of the Department of Horticulture and Natural Resources, Kansas State University, and author Yuijin Park is part of the College of Integrative Sciences and Arts in the Arizona State University The source was posted on Science Direct, an Elsevier platform for peer-revied journals in the sciences and used mostly by universities such as Rutgers University, The City University Of New York (CUNY) and Arizona state university. I intend to use this source to introduce the many changes to which hydroponics can adapt and overcome with ease and as a form of evidence that can support my claims on why hydroponics can adapt to change better.

Beneficial bacterial and fungi in hydroponic systems: Types and characteristics

(Lee, Seungjun, and Jiyoung Lee. "Beneficial Bacteria and Fungi in Hydroponic Systems: Types and Characteristics of Hydroponic Food Production Methods." *Scientia Horticulturae*, vol. 195, 2015, pp. 206–15, <u>https://doi.org/10.1016/j.scienta.2015.09.011</u>.) in this article the authors

breakdown and analyse the six different types of traditional hydroponic systems such being the Wick system, the drip system, water culture system, Ebb-Flow system, the Nutrient film technique and the Aeroponic system. Each of them is broken down and explained as well as how hydroponics is labour effective, easier to maintain sanitary standards, water efficiency and quality and quantity of the crop. The authors debate that with hydroponics traditional labour practices are eliminated making it easier to manage in terms of personnel and with hydroponics one can control the amount of nutrients being fed to the plants which ensures all plants receive equal nutrients. The authors are researchers and graduates of environmental science of the Ohio State University. The source was posted on Science Direct, an Elsevier platform for peer-revied journals in the sciences and used mostly by universities such as Rutgers University and The City University Of New York (CUNY). I intend to use this source for evidence and examples of why hydroponics are beneficial and why these are more effective being grown in areas that cannot support agriculture such as lands with contaminated soil and highly urbanized lands such as New York City.

<u>Comparison of land, water, and energy requirements of lettuce grown using hydroponics vs</u> <u>conventional agricultural methods</u>

Barbosa, Guilherme Lages, et al. "Comparison of Land, Water, and Energy Requirements of Lettuce Grown Using Hydroponic vs. Conventional Agricultural Methods." *International Journal of Environmental Research and Public Health*, vol. 12, no. 6, 2015, pp. 6879–91, https://doi.org/10.3390/ijerph120606879. In this article the authors compare hydroponics and conventional agriculture where it is determined that not only does conventional agriculture requires vast amounts of land, they also waste over 30 percent of the water that is used on them,

but hydroponics do not because they can be built vertically and use ultimately much less water. The authors argue that as land and water become scarcer city planners will introduce more energy effective hydroponics. The authors are part of the Arizona state university, more specifically the school of sustainable engineering. The article was posted on the international journal of environmental research and public health. I intend to use this source as evidence to argue why hydroponics are so effective to be run and installed in highly urbanized environment compared to conventional farming.

<u>Fresh bell peppers consumed in cities: unveiling the environmental impact of urban and</u> <u>rural food supply systems.</u>

Srinivasan, Kumar, and Vineet Kumar Yadav. "Fresh Bell Peppers Consumed in Cities: Unveiling the Environmental Impact of Urban and Rural Food Supply Systems." *The Science of the Total Environment*, vol. 927, 2024, pp. 172359–172359,

https://doi.org/10.1016/j.scitotenv.2024.172359. In this article the authors analyse the environmental impacts of food supply systems in both urban and rural areas and how hydroponics could contribute to sustainable food security in urban and peri-urban (UPA) areas along with promoting (UPA) which is the best strategy to promote food sustainable cities. The authors argue that hydroponics are 1.7 to 4.3 times more land use efficient than other methods of agriculture because they are soilless and can be grown vertically as opposed to other types of agriculture especially as the world population is set to exceed 9.1 billion by 2050. Both authors are part of the Production Engineering Department of the National Institute of Technology (NIT) in Tiruchirappalli India. The article was posted on Science Direct, an Elsevier platform for peer-revied journals in the sciences and used by universities such as NIT India and the City University of New York. I intend to use this source as evidence to argue that hydroponics are a solution to sustainability and food security in cities along with being able to argue that hydroponics are land efficient as compared to conventional farming techniques.