Universally Accessible Garden Project Proposal

Prepared for:

Dr. Emeka Oguejiofor, P. Eng, and Paul Doiron, P. Eng

St. Francis Xavier University Engineering Department

ENGR 232

Friday, February 7th, 2020

Patrick Burke

Alexa Bushnik

Claudia Fulton

Jesse Gillis

Luka Nizetic

St. Francis Xavier University

Antigonish, NS B2G 2WG

Table of Contents

Summary

Executive Summary

Current methods for obtaining produce year-round pose an accessibility problem. This project aims to create an indoor hydroponic garden that runs year-round and overcomes these problems by being cost efficient and user-friendly.

Introduction

Problem

Current options for growing greens, herbs, and small fruits at home are not widely accessible to many people due to cost, complexity, size, or climate. The goal of this project is to fulfill this unmet demand by increasing the accessibility of the means for households to grow these items. It is important to note that this project does not attempt to completely replace one's diet but provide the ability for one to grow their own supplementary produce.

Background Information

In order to design better indoor gardening technologies, the first step is to investigate existing technologies for indoor horticulture. Two key technologies are hydroponics and aeroponics, which will be more thoroughly discussed in the design selection process section. Most units on the market implement a hydroponic system. These hydroponic units on the market divide into two main categories: fully automated enclosed, fully automated open. Some people elect to build their own home-made "do-it-yourself" (DIY) systems as well. The following section will detail the functionality of each option and their shortcomings.

The fully automated enclosed systems, which include, but are not limited to GroBox, Grobo Solid and LEAF. These systems are "Plug N' Plant", allowing the user to plug the box in, plant the seeds in the pods and the plant will start growing. The general dimensions for these systems are 27" W x 25" D x 62" H which would be about the size of a small fridge. These products are similar to a terrarium, so it is sealed and closed to the atmosphere. They have sensors to control pH levels, nutrient concentration, temperature, airflow, humidity, water level and light. Track the plants growth through an app available on your phone.

Although the closed systems do everything when it comes to growing the plants but there are many issues that comes with it. These products are expensive with a starting price of approximately $2500. Since it is fully enclosed there is no room for expansion, so the number of plants is the limited to the number of pods. Given that they are the size of a small fridge, this would be difficult to put in a home with limited space.

The fully automated open systems are made by AeroGarden and there are many different sizes. All AeroGardens have fully automated grow lights that simulate the sun and have sensors to notify the user when to add water and nutrients. One of their largest products can hold 24 plants and is 36" W x 12" D x 34" H. This system is open to the atmosphere which means the plants are easy to access.

Although open systems are cheaper than the enclosed systems, they can run up to $800 or more which is quite expensive for growing some supplementary produce during the winter. The dimensions for

AeroGarden is quite large and would be difficult to find a location to put in your house. To keep the plants from outgrowing the box, it is required to continually groom some of the larger plants. AeroGarden uses soil-free seed pods to grow a plant but the pods are not reusable, so once the plants have finished growing, more pods need to be purchased, which can be expensive. The house must be maintained at a certain temperature and humidity year-round to keep the plants healthy.

Both the open and closed systems require electrical sources for the lights and pumps thereby increasing the costs of growing the plants.

Building a DIY hydroponic indoor growing system requires extensive knowledge of gardening and hydroponics. he result of a DIY indoor unit is an open gardening system with a large footprint, resulting in . Since it is not automated, it is labour intensive and requires constant monitoring of the water, pH and nutrients levels.

Greenhouses are enclosed external structures where plants are grown in climate-controlled conditions. The walls and roofs are transparent – often glass or plexiglass -- to let in sunlight. In colder climates, they are ineffective during the winter because they need to be heated and require extra lighting, which adds to the cost of running it. They need to be in an open area to get enough sunlight during the day. Greenhouses have a large footprint and may not be feasible an apartments or urban areas where the space is limited. Pests, weeds and air circulations are issues that can occur in a greenhouse than would not be an issue if the system was used indoors.

Need for Solution

It has been determined that a demand for in-home garden products exists and that the current options are not sufficient for meeting this demand. The demand for an increased accessibility for these options is dependent on people having a desire to grow their own produce, which can stem from various reasons.

Firstly, those unsatisfied with the produce offered at their local supermarket stand to benefit from their own production. Many options offered in grocery stores are distributed by large scale supply chain models which can under-serve areas where it is not as economically viable, such as remote rural areas. A survey conducted by the Nunavut Bureau of Statistics in 2016 found that the price of food in the Territory can cost as much as three times the national average, due to the high cost of transportation to these areas. This area resides in a colder climate where farming is not viable and has not been achieved. The traditional inhabitants of the area, the Inuit people, existed almost entirely on hunting for food. This highlights a need for fresh produce that could be potentially grown at home.

Second, people are incentivized to grow their own foods due to the benefit of locally sourced produce. Sourcing from distance requires methods to preserve food that can hamper food quality and pesticides implemented by large scale production can compromise the health of foods. The Center for Eco genetics and Environmental Health, University of Washington, cites studies finding that chronic, low-dose exposure of pesticides can lead to respiratory issues, memory disorders, birth defects, and cancer. The transportation of food over long distances also requires preservatives known to have adverse health effects. The methods for transportation also pose an environmental risk and use energy.

Third, there is an already existing demand for in-home garden products. AeroGrow, a publicly traded company specializing in home garden products, holds a market cap of over forty million ($40M) dollars as of February 2020. While this asserts a demand for these products, the price for these units isolates the availability to higher income earners. As a result, there is still a need for more accessible options.

Design Selection Process - Solving the Problem

Criteria

When looking at developing an in-home garden that is more accessible than those already on the market, we had to consider many different criteria. After research and discussion, it was determined that a successful project would incorporate three main criteria:

1. Accessibility
2. Efficiency
3. User-friendliness

The main objective of this project is to create accessibility through affordability. This means keeping the costs as low as possible, while providing a high-quality product that is reliable. When it comes to efficiency, the produce must grow produce as fast as possible, without having large operation costs to come with it. The garden should be efficient in its power and water usage, so not to raise the bills at home. The third criteria is user-friendliness, meaning the garden must be easy to use by someone without technical skills. Set up and required maintenance such as cleaning should also be easy. This project aims to raise the standard in this market for these three previously mentioned metrics.

Type of gardens

There are a variety of growing mediums used in indoor gardens. Several options were researched as possibilities, all of which have unique benefits and disadvantages. The conventional method is planting directly in soil. The advantage of this type of garden is its simplicity, and its familiarity to people who may have grown vegetables outdoors before. These gardens are also more forgiving then hydroponic setups, since the latter dry out much slower if the water supply is interrupted. Unlike the other growing mediums researched, soil gardens often require pesticides, of which some of the negative effects have been previously stated.

The most widely used alternative to a soil garden is a hydroponic setup. In this setup, the roots are placed in another porous material such as coconut fiber or gravel. A nutrient solution is then pumped through to deliver water and nutrients. Hydroponic gardens grow faster than soil gardens and yield more produce. Since the runoff solution drains back to a reservoir, more water is conserved and recycled. They are also pest resistant. The downside of these systems is the complexity added by introducing electronic and mechanical systems which includes but is not limited to power supply, pump, sensors. Plants in these gardens can also be at risk when the system fails, due to the reliance on mechanical processes. There are many possible configurations for hydroponic systems, diagrams of two hydroponic setups considered for use in our project can be found in the Appendix.

The final growing medium considered is an aeroponic system. In these gardens the plant's roots are left suspended in the air and misted with a nutrient solution. These systems are even more water and nutrient efficient than hydroponic systems and grow faster and yield more. They are also more space efficient as the plants are not competing for nutrients. The downside of these systems Is the additional added complexity, since Aeroponic systems require more maintenance and inspection. Since water and nutrients are very specifically targeted to the plants, any failure in the system will cause the plants to die very quickly.

With the information and the criteria presented above, it has been determined that the project will implement a hydroponic set up. This type of system maximizes efficiency without unnecessary complexity.

Project Specifications - Plants Growing Needs

Plants need certain conditions to grow properly. While designing this garden, the biggest problem will be making sure the plants are provided with everything they need. A pH of 6.0-6.5 will need to be maintained for the plants to absorb the optimal level of nutrients. The solution also must consist of nitrogen, potassium, phosphorus, calcium, magnesium, Sulphur, iron, manganese, copper, zinc, molybdate, boron, and chlorine to provide the plants with all the needed nutrients. The air humidity in the unit will also have to be adjusted because the average humidity in a house during the winter is around 30-40% while plants require at least 50% humidity, some needing up to 70-80%. The recommended temperature of a hydroponic unit is within the range of 17-25°C which is around room temperature meaning our design will not have to maintain a temperature. Most plants that we are looking into including as options grow to be around 1-2 feet tall, which will be a main deciding factor in our design dimensions and take around 2-3 months to be ready to harvest.

Taking all these needs into consideration the garden will likely be able to grow this variety of plants:

- Leafy Greens: Lettuce, Spinach, Kale, and Cabbage
- Herbs: Basil, Parsley, Cilantro, and Mint
- Dwarf/Cherry Tomatoes
- Mini Bell Peppers
- Strawberries

Analysis

Engineering Aspects

This project will require the use of engineering applications learned in the engineering courses.

Creating the hydroponic solution will take chemical engineering. The pH must be kept constant and within a certain range along with a balanced nutrient content for the plants to thrive. A big problem for this project will be meeting this criteria and skills learned in our first-year chemistry labs will help with the task.

The unit will be designed in a way that looks appealing and can support all the weight of the plants and equipment. We will utilize our skills learned in Design & Graphics and Strengths of Materials classes to do this.

Our plan to make our garden easy to use for consumers requires that most of the working parts be automated. This will require writing code for a microcontroller and possibly creating a circuit board. Using aspects from the Computer Programming and Circuits courses will allow us to accomplish these tasks.

The use of a water pump for the hydroponic solution will require calculations taught in our Thermo-Fluids course to adequately analyze the system.

Timeline

Stages of Project

The project will consist of three stages: the design stage, build stage, and the analysis stage. The design stage includes finalizing dimensions for the garden, designing the hydroponic system and enclosure, finding out what components are needed for the prototype, and creating AutoCAD/Inventor drawings. The build stage will start after our components are received and will last around two weeks. This stage is planned to be finished three weeks before the end of the project to leave enough time to test growing a species of plant. The analysis stage will have two parts: the engineering analysis and the economic analysis. The engineering analysis will include all the calculations and planning around the engineering aspects of our project, outlined in the Engineering Aspects of this proposal. The economic analysis will look at the cost of materials and components as well as the ongoing cost of operating our garden.

Gantt Chart

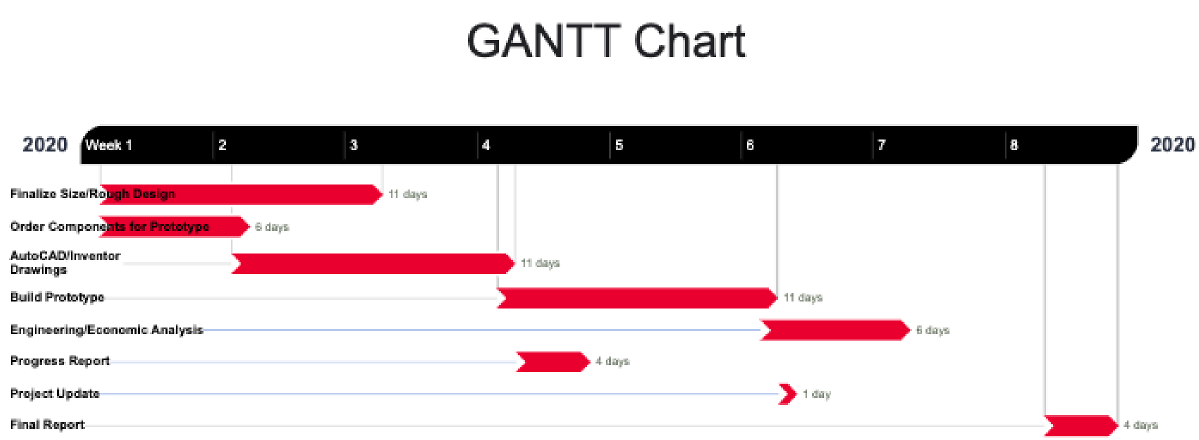

Figure 1

Conclusion

The goal of this project is to increase the accessibility of home garden options by creating a unit that is user-friendly and of reasonable size and cost. Indoor garden options are limited and by creating a new design, more consumers will be able to supplement their diet with fresh vegetables and smalls fruits.

Appendix: Hydroponic Systems

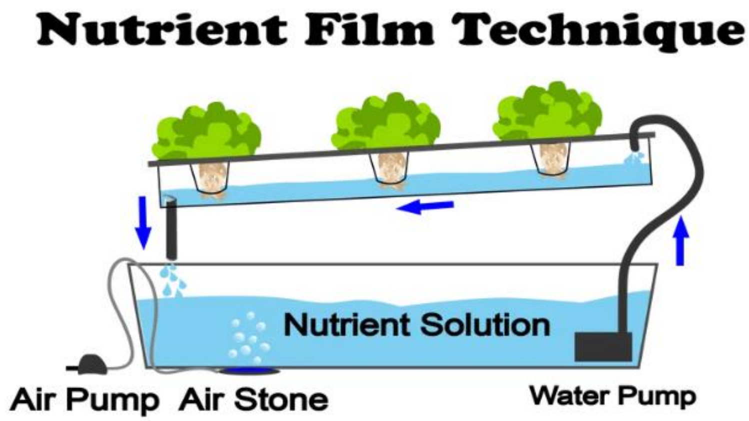

Figure 2

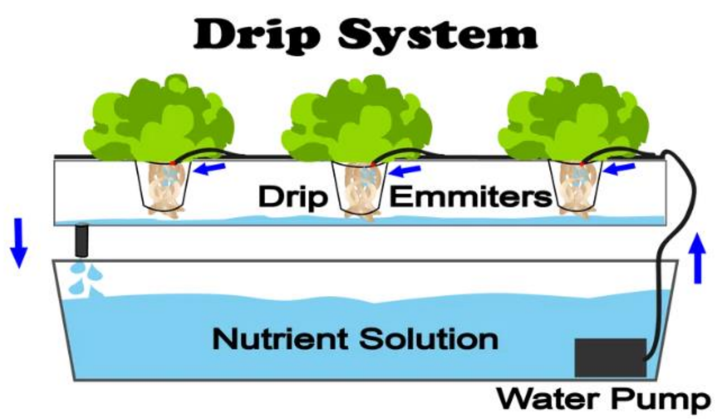

Figure 3

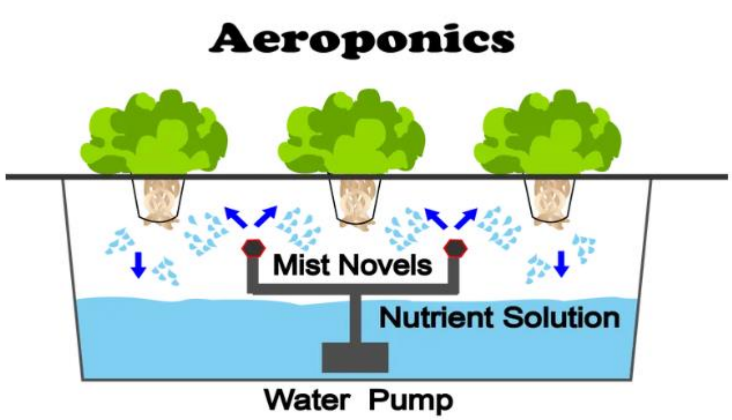

Figure 4

References

"10 Best (Easiest) Plants to Grow Hydroponically Indoors." *Heal With Food*, www.healwithfood.org/grow-indoors/best-plants-to-grow-hydroponically-or-aquaponically.php. Accessed 29 January 2020.

"AeroGarden – Indoor Gardens." *AeroGarden Official Store,* www.aerogarden.com/. Accessed 28 January 2020.

"AeroGarden Farm Plus Hydroponic Garden, 24' Grow Height, Black." *Amazon.ca: Patio, Lawn & Garden,* www.amazon.ca/AeroGrow-900971-1100-AeroGarden-Farm-XL/dp/B073W7TNH6/ref=sr_1_1?keywords=aerogarden&qid=1581035763&sr=8-1&th=1. Accessed 28 January 2020.

"Basic Hydroponic Systems and How They Work." *Simply Hydroponics*, www.simplyhydro.com/system/. Accessed 25 January 2020.

Cloudponics. "GroBox." *Cloudponics,* cloudponics.com/pages/grobox. Accessed 28 January 2020.

"Design and Build Your Own Aeroponics System." *Aeroponics DIY,* aeroponicsdiy.com/. Accessed 28 January 2020.

Garfield, Leanna. "Food Prices Are Insanely High in Rural Canada." *Business Insider*, 21 Sept. 2017, www.businessinsider.com/food-prices-high-northern-canada-2017-9. Accessed 28 January 2020.

Grobo. "Grobo Solid." *Grobo*, www.grobo.io/products/grobo-solid. Accessed 28 January 2020.

"Grow with LEAF." *LEAF*, www.getleaf.co/. Accessed 1 February, 2020

"Health Risks of Pesticides in Food" 2013. PDF File. https://depts.washington.edu/ceeh/downloads/FF_Pesticides.pdf. Accessed 30 January 2020.

Kolifrath, Jessica. "Greenhouse Growing Problems." *Home Guides | SF Gate,* 7 October 2016, homeguides.sfgate.com/greenhouse-growing-problems-48741.html. Accessed 28 January 28, 2020.

Lee, Winnie. "Glowing Dutch Greenhouses, As Seen From Way Up High." *Atalas Obscura,* Atlas Obscura, 28 January 2020, www.atlasobscura.com/articles/glowing-dutch-greenhouse-photos?utm_source=Atlas%2BObscura%2BDaily%2BNewsletter&utm_capaign=6636ef3149-EMAIL_CAMPAIGN_2020_02_03&utm_medium=email&utm_term=0f36db9c480-6636ef3149-70863833. Accessed 1 February 2020.

Sela, Guy. "Hydroponic Nutrient Solutions." *SMART - Fertilizer Management*, www.smart-fertilizer.com/articles/hydroponic-nutrient-solutions. Accessed 29 January 2020.

Spengler, Teo. "Hydroponic Water Temperature." *Gardening Know How*, 4 Apr. 2018, www.gardeningknowhow.com/special/containers/hydroponic-water-temperature.htm. Accessed 29 January 2020.

Storey, Amy. “The Beginner's Guide to Hydroponic Tomatoes.” *Upstart University*, 16 Apr. 2019, university.upstartfarmers.com/blog/hydroponic-tomatoes. Accessed 29 January 2020.

“What Is The Best PH For Hydroponics?” *Smart Garden Guide*, 26 Sept. 2019, smartgardenguide.com/best-ph-for-hydroponics/. Accessed 29 January 2020.