# Smart Hydroponic System

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*(no sponsors currently involved)*

Initial Project and Group Identification Document

# 2. Project Description

## 2.1 Project Functionality

This project will consist of a hydroponic system that features a well-equipped controller for automation, an on-board control panel, and an fully integrated mobile application for wireless control and monitoring.

### 2.1.1 Hydroponic System

Hydroponics is defined as the process of growing plants in sand, gravel, or liquid, with added nutrients but without soil. There are many different ways to go about constructing a hydroponic system, but this project will focus on what is called a Nutrient Film Technique, or "NFT" for short. The NFT system is what most people think of when they hear the term "hydroponics". It consists of a simple growing medium such as PVC pipe and a constant flow of nutrient solution coming from a reservoir. The plants being grown are placed in the growing medium with their roots exposed the the nutrient solution, which they naturally reach out to for nourishment. The constant flow of nutrient solution is achieved by a feeder line coming from a submerged pump within the reservoir going to the growing medium and finally ending with a return pipe to the reservoir (**Figure 1**). A slight tilt of the growing medium allows the nutrient solution to flow down to each of the plants by using gravity, eliminating a need for a pump at the front end of the medium. Also seen in **Figure 1** is an air stone inside of the reservoir. The air stone is key to having a good nutrient/water solution as well as keeping the water from becoming stagnant. All of these components working in harmony are essential for the basic hydroponic NFT system.

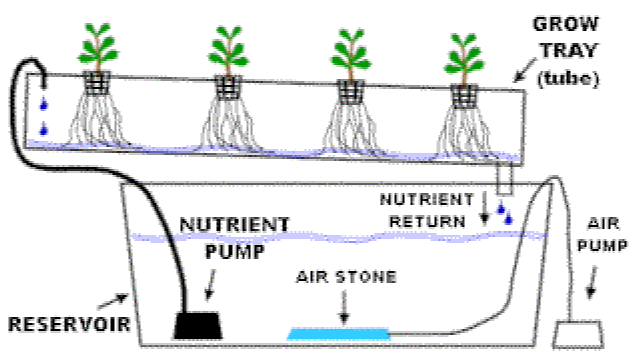



**Figure 1**

### 2.1.2 Control Unit

The hydroponic system will be very straight forward and easy to use. Various sensors will be implemented and the information will be displayed on the platform itself. This information will also be accessible remotely via a wireless device. It will give real time information about the system and alerts when necessary.

- **Sensors**
  In order to ensure the plants are growing in ideal conditions, a significant amount of sensors would need to be implemented. These sensors include a pH sensor to give real-time information about the pH level of the water flowing through the system and in the reservoir. Two (2) electric thermometers to continuously measure and record the temperature of the water flowing through the system as well as the air surrounding it. An electric Hygrometer to measure and record the humidity of the air surrounding the system. A water level sensor will also be implemented to make sure the reservoir does not breach a given threshold or completely drain.

- **Internet Connectivity**
  The user will be able to interact with the system remotely using a wireless device via a mobile phone. He/she will be able to check water levels, pH level, both water and surrounding air temperature, air humidity, etc.

- **Power Control**
  The system will be powered from the building it's being used in. An AC-to-DC converter will convert the current from an outlet in the household to direct current for the system to be able to function properly.

- **System Control**
  The system will be equipped with an on-system, non-touch display. This display will have four (4) buttons that allows the user to navigate to different menus to see real-time data about the system.

- **Hardware**
  In order to allow the system to operate to its full potential, allowing the plants to grow in ideal conditions, a few more hardware items will be implemented. Some of these include a pump for the water to continuous flow through the system and remain non-stagnant, an air-stone at the bottom of the reservoir to supply the water constantly with oxygen, an on/off power switch to allow the user to shut-down the system safely, and a manual control to add nutrients to the reservoir when needed.

- **Leak-proof Plumbing**
  Due to the nature of this project, special precautions must be taken in the design to ensure its functionality and durability. Careful attention will be paid when putting together plumbing fittings to ensure there are no leaks within the system.

- **Electronics Protection**
  All electrical components must be properly insulated to avoid any short circuits in the system. This is very important as water may not only come from within the system but from the user.

- **Minimal Power Consumption**
  The system will run off of electricity provided from main grid to their home. Therefore the system will be designed to consume minimum energy. This will ensure the consumer does not experience a noticeable change in their electricity bill.

- **Low Cost**
  Careful consideration will be taken when choosing each component of the system. Cost, quality, and effectiveness of each component will be reviewed before items are purchased. This will ensure the development of a robust, inexpensive system that the average consumer will be able to afford.

- **Maximize Space Efficiency**
  Space efficiency will be a very important aspect in the design of the project. This project is being designed to be used indoors and outdoors. Therefore, this project should be able to fit comfortably within a household and not be cumbersome.

### 2.1.3 Mobile Application

A mobile application will be designed to receive all data measurements from the sensors in the main unit. The main unit and the mobile application and the main control unit will utilize wireless communication to transmit and receive sensor data. A User will be able to view all current sensor data readings of the system from the main control unit. A User will also be able to indicate the species of plant they intend to grow in the hydroponic system. Based on the indicated plant species, the mobile application will provide the user with all relevant information for growing that species of plant in the hydroponic system, including ideal water conditions, air conditions, light conditions, and nutrient solutions. This information will be available in the application for a wide variety of plant species. The application will also provide automated and manual-override scheduling of nutrient dispensing and light control specifically set to create the ideal conditions for the selected plant species. The mobile application will provide the user with a plant growth tracking timeline based on the user's indicated plant species. Alerts will be generated to the user by the application if the sensor data indicates severely harmful water, air, or light conditions affecting the plants. If incorrect water conditions are detected by the application, the application will generate instructions for the user to rebalance the system to normal. For example, if the sensor data indicates the pH level is too high or too low, then a set of instructions is presented to the user to add a correct amount of balancing chemicals to the reservoir.

The mobile application will be carefully designed to emphasize heavily on an intuitive user interface (UI) and user experience (UX). The UI/UX aspects of the application are to be implemented following Google's *Material Design* principle. This principle is culmination of many visual design, space and system of motion to provide a unified definition for UI design. *Material Design* combines many classic elements of design to create hierarchy, meaning and focus to immerse the user in the experience of the application.

### 2.2 Project Objectives & Goals

In recent years, the use of hydroponic systems by amateur gardeners and fully functioning farms has increased drastically. As cities continue to grow and people become more aware of where their food is coming from, people are demanding properly raised, organic crops at a steadily increasing rate. To help fight this, hydroponic systems have been developed so that the urban farmer can exist in harmony with the traditional farmer.

However, the traditional farmer is also adapting to this change and can now reap the many benefits of using hydroponic greenhouse systems versus traditional soil-based farming. In comparison, some systems can output 30% more produce at a 25% faster maturity rate and, initially, statistics like these are what attracts the transition from soil-based farming. Unfortunately, there is a tradeoff. In general, hydroponics systems are more expensive, can be complicated for beginners, and demand a lot of attention. These disadvantages can scare away potential farmers, especially in an age where the majority of consumers would like to buy rather than take on a do-it-yourself project.

This project will look to tackle the disadvantages of hydroponics while bringing to the consumer a product that allows them to take all of the benefits from their system. The main goal is to provide the urban and metropolitan-based populous with a way to grow their very own, organic food in the comfort of their home with unprecedented accessibility to their system. Project based goals include the following:

- Construct a compact, durable, and convertible hydroponics system for use in all environments and locations (indoor/outdoor).
- Develop a system that can be used by both entry-level and expert users.
- Provide real-time system monitoring in order to aid the user throughout the growth cycle of their desired produce via a mobile application.
- Create a user friendly experience in both the mobile application as well as the physical interaction with the system.
- Educate and inspire users to continue to foster an interest in hydroponics as a way to grow their very own food, no matter where they live.

### 2.3 Statement of Motivation

The decision to design an intelligent hydroponic gardening system is supported by several different motives. One of the main supporting reasons behind this decision is to provide the ability to easily grow and sustain food yielding plants in an otherwise improper indoor or outdoor environment. This system is intended to be located conveniently inside a residential living space, such as an urban city apartment, rental property, or townhome and could also be modified and utilized in expeditions where the ability to grow food with an abundant power source is needed. The consolidated and compact design of the unit is intended to limit the physical space occupied by the main unit and to provide more convenience to users.

The system also provides a mobile application is intended to provide the user with guided real-time instructions for growing many different species of plants of their choosing. The mobile application is intended to provide an elegantly intuitive design for the user's experience. The robustness of the application is necessary to accommodate a low barrier of entry for the user. Lastly, a few indirect benefits from this system include: the ability to promote consumption of fresh and healthy foods, the plant's production of clean oxygen during indoor use, a reduction in the use of fertilizer and pesticide, and an improvement in conservation awareness.

# 3. Specifications & Requirements

### 3.1 Physical Structure

- Open-air tower structure, approximately 3 feet tall with the water reservoir mounted underneath the base of the structure containing about 10 gallons of water.
- Main tower structure contains about 15-20 plant bays for plants to grow out of. The plant bay will be slightly slanted outwards at an angle from the center of the tower. This configuration allows for gravity to assist in water drainage back into the reservoir.
- The system should have ease of mobility via wheels mounted to the underside of the main hydroponic tower.
- Weather-proof LED light fixtures mounted to the structure and properly aimed towards the plant bays.
- TODO LED light wavelength
- An even amount of light should be projected to all plants on the tower.
- The tower structure should be able to easily support 100lbs of constant, downward force to adequately remain standing while supporting the load of running water and plant growth.

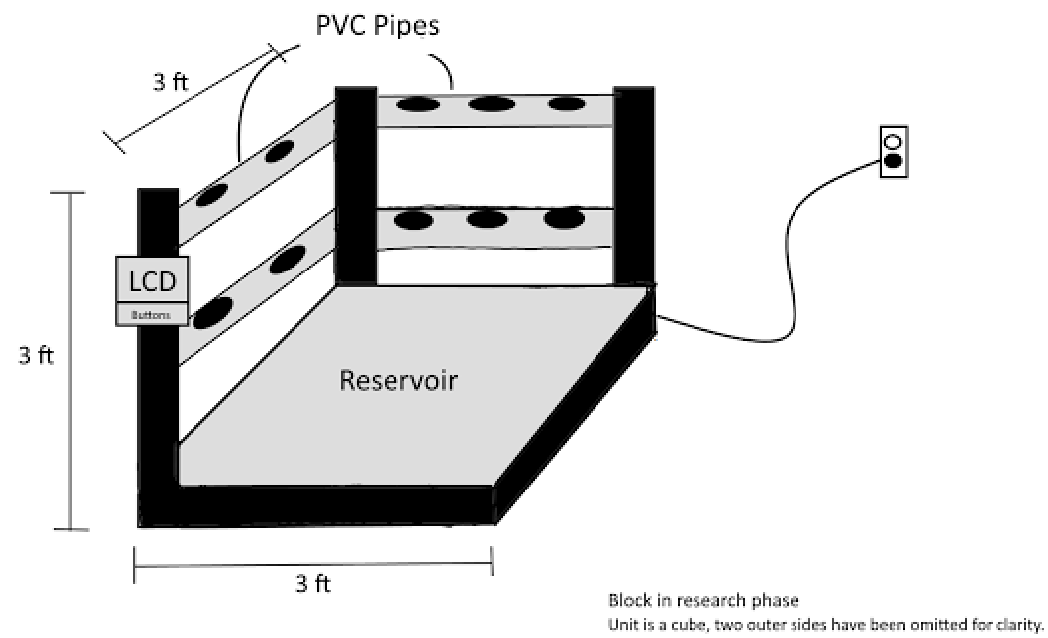
### 3.2 Water System

- The water pump must be strong enough to pump water up and through the tower system. Experts recommend that the system volume should be pumped completely every two hours. This implies that for a ten gallon system, the water pump should be able to pump at the minimum rate of five gallons per hour at a head height of about 6ft.
- The ideal pH range for most hydroponic plants is between 5.5 and 6.5. The ideal water temperature range is between 65 and 80 degrees fahrenheit. The nutrient strength levels generally range from 800 to 1500 ppm, depending on the current growth phase cycle that the plant is in.
- An oxygen stone will be needed to reside in the water reservoir in order to properly oxygenate the water as it is pumped to the plants.

# 4. Block Diagrams

Note: Unless otherwise stated, all blocks are in research or design phase.

Basic Main Unit Prototype Design




High-Level Overall Project Block Diagram

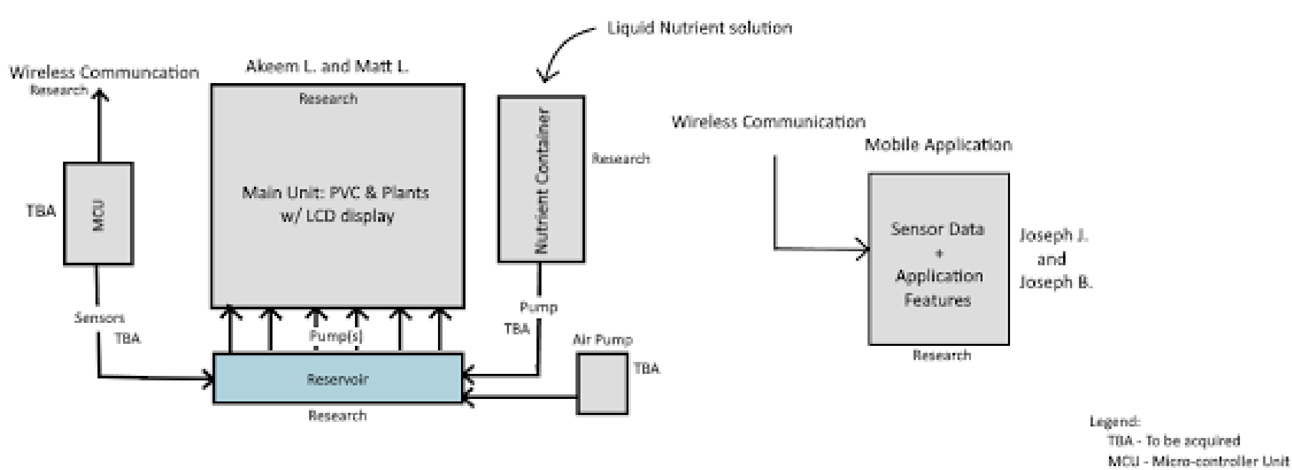
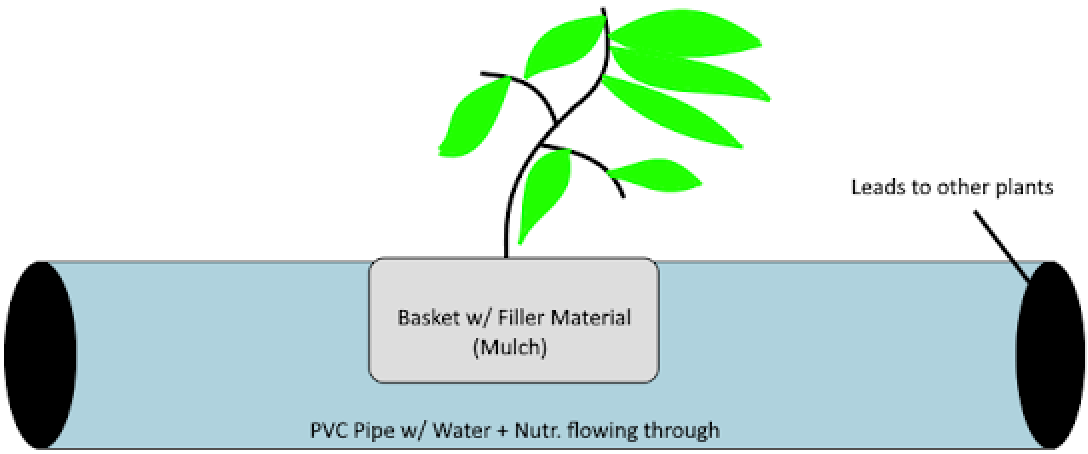
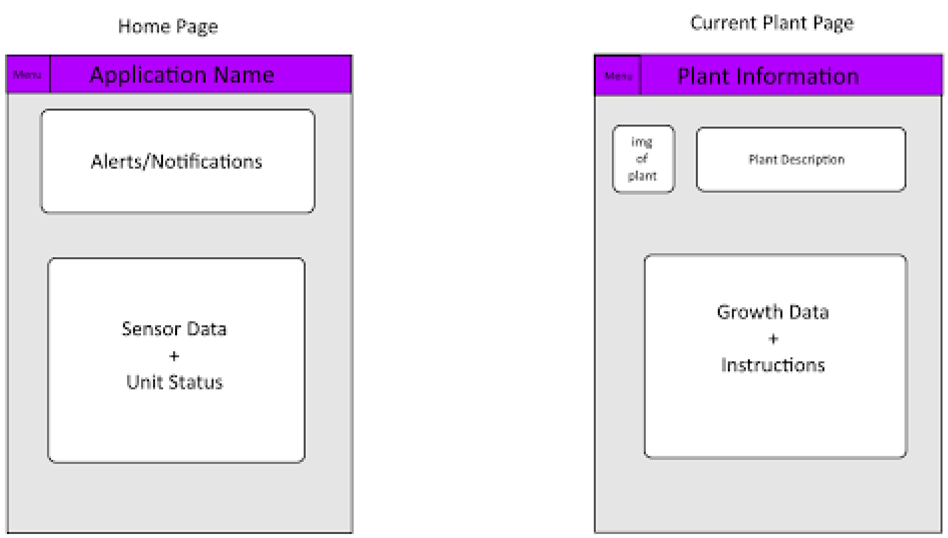


Diagram of PVC Prototype Design




Mobile Application Design Prototype




## 5. Budget & Financing

While still in the research phase of development, the figures below are subject to change. These are all rough estimates of product pricing after doing some browsing. In addition to budget research, some financing research has also been conducted and we are looking to secure around $1000.00 in funding, a figure we currently see fit for completing the project with some room for error.

- Air stone and air pump - $30.00
- Nutrient pump - $45.00
- Growth medium and components - $100.00
- Sensors - $150.00
- Physical structure - $100.00
- PCB board assembly - unknown
- LCD Control panel - unknown

For the mobile application section of the project, the budget is currently projected to be very low cost, as most of the required software and implementation is open source or free.

# 6. Project Milestones

### 6.1 Semester 1 Milestones

- Finalized design for structure of main unit
- Finalized design for mobile application
- Selection of appropriate liquid pumps and air pump
- Selection of appropriate lighting system
- Exhaustive list of desired sensors and expected uses
- Design of appropriate PCB layout
- Completed prototype of mobile application UI design
    - Design and navigation without implementing features

### 6.2 Semester 2 Milestones

- Construction of main unit
- Integration of sensor array with PCB
- Integration of LCD display with PCB
- Integration of wireless communication with PCB
- Implementation of control panel buttons
- Mobile application functionality
- Successful growth of a plant