

Design Criteria and Target Specifications

1.0 Introduction

Our team sets out to develop a cost effective crop growing solution that can be implemented and utilized by individuals living in areas that do not promote the natural growth of vegetation. The crop growing solution will be utilized by a population that is under economic duress and as such water usage, power requirements, and material availability must be taken into consideration. The idea of growing sustenance with as few resources is not a new concept, it is actually one of the oldest design problems of human history, and as such many designs have been generated to solve this problem. Our teams problem in particular has a specific user that has not been the target of previous designs. The solution that we develop will have to be unique from previous designs to meet the needs identified from the user. The needs of the user have been identified as the following.

- Low Cost
- Low maintenance
- Low water usage
- Low power usage
- Adequate crop yield to feed a family
- Size/Portability
- Retains heat overnight
- Not affected by poor soil conditions
- Produces Quality vegetables
- Easy to use
- Ability to use gray water

Although the above set of needs are unique to our specific target community, other solutions to similar problems have been identified to satisfy one or more common needs.

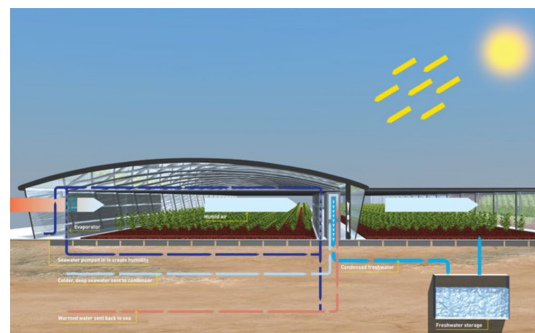
2.0 Benchmarking

Benchmarking will be performed to understand the current market for growing solutions. With benchmarking, we will quantify the design specifications in order for our design to compete in the current market.

2.1.1 Desert Farming Solution

A benchmarked solution that we have identified as being related to our own problem is a design created for mass produced desert growing. The purpose for this design is to allow farmers to grow valuable produce in the desert for financial gain^[1]. This project has not yet been fully implemented but three pilot projects are currently being executed and the design is very interesting to our team. The desert growing design is a low power use greenhouse that uses salt water to provide hydration to the plants, see figure 1^[1].

The greenhouse structure in the design is large and should be implemented for large scale growing projects. The system works by piping in salt water from the sea, be it by gravity or mechanical means, to the greenhouse facility^[1]. Just as humans cannot consume salt water for



hydration, plants too need fresh water to grow. This design utilizes the strength of the sun in desert climates to provide the energy for the conversion process between saltwater and freshwater. The salt water is piped into thin honeycomb structures at the top of the greenhouse where the sun is the most direct. The salt water evaporates leaving all of the salt behind then condensed back into liquid form^[1]. Once condensed, the once salt water is now fresh water and can be stored for use in the greenhouse irrigation system^[1]. A positive side effect of this water treatment process is the humid climate inside the greenhouse that results from the evaporated salt water^[1].

Figure 1: Displays the design for a desert farming solution for the purpose of selling grown produce.

The scope of this design is very different from scope of what we are attempting to develop, however, aspects of the design do fulfill some of our projects identified needs. The first need that this solution meets is low water usage. This solution does not utilize any fresh water in the irrigation process and only uses salt water that is useless for human consumption. The second identified need that the desert farming design meets is low energy usage. By utilizing the sun for the distalization process and providing plant light, this system can operate with only a few pumps for water transportation^[1]. A third need that is satisfied by this design is the production of quality produce. The greenhouse design is enclosed and protects the crop from both bad weather and pests that would otherwise adversely affect the quality of harvest. The fourth and final need this design addresses is that the growing solution does not depend on the soil quality of the area. On the inside of the greenhouse is a raised section that allows the farmer to use any quality of soil he or she wishes. This solution does not meet the following needs for various reasons: low cost, low maintenance, temperature control, ease of use, and size/portability.

2.1.2 Drip System

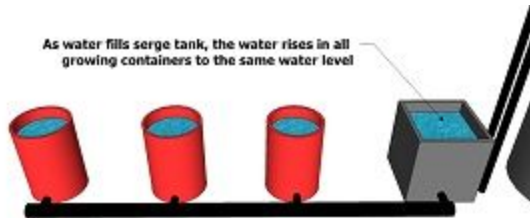
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Building a small and affordable hydroponics system can be relatively simple. The drip system is a cheap and effective way to build a hydroponics system. For around 100 dollars the following list of materials can be purchased to create this small scale hydroponics system: four five gallon buckets to hold the plants in, four bulkhead fittings, black vinyl tubing for the drain and fill lines, a pump for the water, a storage container for the water between 18 and 30 gallons, a hydroponics growing medium, a furnace filter to prevent the medium from getting into the lines, t connectors for the vinyl tubing, and dark coloured paint to light proof the bucket reservoirs. Using these materials a hydroponics system can be created to support the growth of four plants. Specially designed hydroponic nutrients could also be added to encourage the growth of crops in the system. The aspects of this system that satisfy our design criteria are its low cost, ease of assembly/maintenance, production of quality vegetables, and capability to sustain a small family. The negative aspects of this system are its heavy demand on water, its inability to use grey water, and its dependence on special nutrients to strengthen the soil.

http://www.homehydrosystems.com/hydroponic-systems/ebb-flow_systems.html

2.1.3 Flood and Drain System

Another variation of the hydroponics growing system is a flood and drain system. This system requires the plants to be orientated in a series formation (Figure 1.1).



This orientation is rather straight forward, and can be set up both indoors and outdoors. The plants are held in the main part of the system (far right on above diagram). A timer is set on the pump to control when the water flows through the vinyl pipes. The water continues to fill the main system until the plants roots are soaked. This is a preset volume of water that can be actively altered depending on user's desire. The water's elevation is altered through the use of an overflow tube (Figure 1.2); a tube which sets the height of the water and ensures that the water does not overflow while the pump is running. When the water reaches the overflow tube, the pump shuts off and the water is siphoned back into the reservoir where it can be reused for the next periodic cycle.

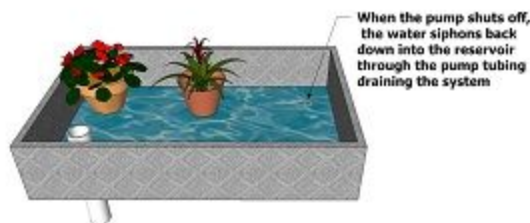


Figure 1.2

This system has many aspects which would be beneficial to a hydroponics system being used in a refugee camp. This system is easy to use/maintain, it can be easily moved and does not require lots of space, it constantly reuses water, it produces quality crops, and the materials used in its design are cheap. The negative aspects of this system are its dependence on freshwater and electricity for the pumping mechanism.

Materials that are required to build a Flood and Drain System

- container for the plant's roots to grow in.
- reservoir to hold the nutrient solution in.
- submersible fountain/pond pump.
- light timer to turn the pump on and off.

- tubing for the nutrient solution to be transferred from the reservoir to the pump to the system
- overflow tube
- growing medium for the plants.

2.2 Summary of Benchmarking Data

The below tables summarize the data collected from benchmarking similar designs. The first table analyses each benchmark to what we have deemed critical criteria and the second table analyses each benchmark to what we have deemed non-critical criteria.

3.0 Design Specifications

Design Spec	Relation (<,>=)	Value	Units	Verification Method
Functional Requirements				
1. Cost	<=	N/A	\$	
2. Size	<	2	m ²	Measure
3. Temperature	<	30	C°	Test
4. pH	~	5.5-6.5	pH	Test
5. Power	<	12, 50	Volts, Amps	Measure
6. Water	<	500	Litres	Measure
Non-Functional Requirements				
7. Weight	<=	1	Carrying capacity of 2 avg human	Test

8. Yield	=>	15000	Calories	Measure
9. Safety	<	500	PPM	Measure
Constraints				
5. Cost	<=	\$200	Canadian Dollar	Measure

<http://www.simplyhydro.com/ph.htm>

4.0 Target Metric Range

The functional requirements are the needs that are supposed to be accomplished by the system. The biggest functional requirement for this system is that it must have a low cost so that the system can be afforded by NGOs supporting the camps. This can also be considered a constraint because if the system costs too much then it will become unaffordable for the camps. Another functional requirement for this system is that it must be a low water and power system because the refugees camps have a limited amount of water and power. The third functional requirement is the system must be durable enough to withstand sandstorms, drastic temperature drops, and pests contaminating or confiscating the crops. The last functional requirement is that system must be contained within the amount of a space that is given. A non functional requirement for this system is the appearance of the system because it is not an essential design requirement for our system. This is the only non-functional requirement as it is very important that all of the above needs are met.

There are many constraints to take into consideration when designing the system. The cost for it must be low enough (\$200) so that the NGOs funding the camps can afford to implement the system for the most families possible, be durable enough to withstand the weather and pests including rats and bugs. The system must have a weight that allows it to be carried by a team of two people (200 lbs), so that it is easy to transport and move around and must be heavy enough to not blow away in high winds. The system must be able to sustainably produce crops for a family of 4 refugees (15000 calories). The system must not occupy a space greater than $2m^3$ so that it can be fitted within the constraints that the camps give the refugees. The system must maintain a minimum internal temperature of 15 degrees celsius for a duration of 10 hours under an external temperature of 0 Celsius, and should avoid temperatures of over 30 degrees celsius. The system can use no more water than the refugees produce as grey water. The last constraint is that the system must run on 12 volts and 50 amps, as electricity is the most limited resource.

5.0 Reflect and Conclude

Like any product, the design of a hydroponics system must be based on the customer's needs. In this report we have summarized both our customer's and user's needs, and used them to define design criteria and target specifications. Although concepts can be taken from other systems, the design of an effective hydroponics system must be unique to the needs of a Syrian refugee camp. The system must be designed of lightweight and affordable materials to accommodate portability and NGO funding constraints. It must minimize the use of electricity and water, while still producing enough crops to sustain a family. Finally it requires ease of use/maintenance, despite being faced with the harsh extremes of a desert climate. These design criteria and target specifications will enable our group to create the most effective product for our customers needs.

References

- [1] "The Future Of Farming: Eight Solutions For A Hungry World". *Popular Science*. N.p., 2017. Web. 2 Feb. 2017.