

GNG 1103

Engineering Design

Project Deliverable J: Final Design Report

A Solution to Improve
the Lives of
Syrian Refugees

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ABSTRACT

Teams of engineering students were given the opportunity to use their design skills in an effort to make a real difference in the lives of people in need. Syrian refugees who have been forced leave their homes because of the ongoing civil war in their homeland have taken shelter in camps in the Jordanian desert where living conditions are extremely harsh and basic human needs are barely met. It was our responsibility to design a hydroponic system that would provide Syrian refugees with a sustainable source of food that is, water efficient, durable, does not require electricity and is cost effective. An effective solution will not only be one that provides food but also one that will allow individuals to regain a sense of control over a small part of their life and the fulfillment of being able to meet some of their basic needs. After gaining a thorough understanding of the needs and circumstances refugees face a list of user requirements was developed. As the design process commenced the user requirements developed into design criteria in which the team ranked the importance of each requirement. This step would provide the foundation in which the design solution would be developed. In addition to design criteria, benchmarking was an important step in the research process to gain a thorough understanding of functioning of hydroponic systems. Although benchmarking is important the team realized that current products on the market do not meet the design criteria required of this project because of the harsh environment and resource limitations that exist. With this knowledge, the team developed conceptual designs that were evaluated and ranked leading to several prototypes to be developed, evaluated, and modified to produce the final design. The final design provides a large planting area, does not use electricity and is durable enough to withstand the harsh elements. In addition, the design takes advantage of temperature differences to maintain the water supply. The application the design is intended for is of great importance to each team member, as it will alleviate the strain of survival for people who have experienced unimaginable hardships.

1.0 INTRODUCTION

The problem presented to GNG Section A that Group 5 was tasked to solve was one that faces Syrian refugees in Jordan. After identifying and prioritizing the needs, it was found that Syrian refugees in Jordan are in need of a cost effective, water efficient and durable way to produce an adequate supply of nutritious food.

1.1 User Requirements

The data presented to us was obtained in a question period with a former Syrian refugee named Mohammed. From the data he presented, we formed the following list of user requirements:

- The solution is water efficient.
- The solution is cost effective.
- The solution does not rely on electricity to function.
- The solution can withstand dust storms and drastic changes in temperature.
- The solution has ease of set-up and operation.
- The solution can provide refugees with a variety of plants.
- The solution can reliably supply food to support one or more families of refugees.
- The solution does not place a large burden on the users.
- The solution's crop is not vulnerable to vermin.

1.2 Key Aspects

The cost-effectiveness, water efficiency, durability and non-reliance on electricity makes this design unique compared to other products that are currently on the market. The design process led us to a prototype that attempted to meet these key aspects. The final design is cost-effective despite its initial cost. This higher initial cost is due to the design's capability to support multiple families of refugees with its larger crop yield. It is important to note that there are no additional costs beyond the initial price. In addition, durability of the product not only eliminates many possible maintenance costs, but also helps mitigate water use and waste. The initial water requirement is quite large and we realize this is an issue but the manual cyclic nature of the system's water usage enables users to nurture their crops with the same water supply without the use of electricity, making it water efficient since the users cannot be expected to take water from their rations to replenish the supply once there is enough water in the system.

2.0 DISCUSSION

2.1 The Client

Our group was tasked with creating a hydroponic system for refugees in Jordan where the living conditions are dire and worsened by the harsh weather conditions (Rainey, para. 4). Located in a remote and arid part of the desert in Jordan, many refugees live where there are no toilets, running water or electricity and nearly 95 percent of households do not have enough food (Rainey, para. 5). The need for nutritious food is of great importance. The hardships these people experience are unimaginable and it is our task to somehow find a solution that will provide some relief that they so very much deserve.

This turned out to be a very challenging task to complete due to the harsh living conditions that they experience on a daily basis and the lack of resources available. Yet it is of immense importance to provide an effective solution that will help improve their standard of living. An effective solution will not only be one that provides food but also one that will allow individuals to regain a sense of control over a small part of their life and the satisfaction of accomplishment by being able to grow some of their own food.

When meeting with our client Mohammad, we asked him multiple open-ended questions and obtained very useful information. One of the most important pieces of information we gathered is that the refugee camp is located in the Jordanian desert. Due to the fact that it is located in a desert presents many challenges such as a limited supply of water, large temperature fluctuations, no electricity and few nutrients in the soil.

One of the initial problems to address was the limited supply of water that would be a very significant problem. Being a desert environment there is little to no rain or snow for long periods of time this means the water that the refugees get is from an external source that is supplied by truck from the capital. As a result, it is of critical importance that our design is extremely water efficient and every drop is used in the most effective and efficient manner possible to ensure little to no waste or loss to evaporation.

Along with the lack of water the weather conditions are also challenging. Sandstorms are a regular occurrence, along with extreme changes in temperature. The environment is an important aspect to consider in our design because we have to ensure that the product is built out of materials that are durable enough to withstand the storms and extreme temperature changes from 40 degrees Celsius in the day to below 0 at night.

Although fluctuations in temperature present a problem, it can also be seen as an advantage. If designed properly, the changes in temperature will create a perfect opportunity to take advantage of condensation which will in turn ease the challenges of lack of water.

Another important piece of information we were able to gather from the client is that there are 6 families per tent, with many of them willing to look after the hydroponic system. This was an important aspect for our team because we felt it would be important to set our target yield to be adequate to feed all of the families in one tent.

2.2 Problem Statement

After analyzing the data gathered from the client we were able to create a problem statement in which our team based our design on.

“Syrian refugees need a sustainable source of food that is, water efficient, durable, does not require electricity and is cost effective with ease of use.”

2.3 Design Criteria

Design Criteria from highest to lowest importance:

Following the meeting with the client and creating the problem statement, the next step was to analyse the information obtained and come up with a specific design criterion for our project. There were many important factors that we took into consideration. The first major design criteria is that we needed to ensure that our system required no electricity to function seeing as there is a limited supply of electricity at the camps consisting mainly of batteries the refugees bought.

Another important feature we needed to incorporate is that our design must require very little water to function due to the limited supply at the camp. Cost is another factor our design criteria needed to meet as the system must be inexpensive seeing that the refugees have a limited supply of funds. Although the system must be inexpensive we would also have to insure that it is made out of durable materials to withstand the harsh desert environment. These materials must also require little to no maintenance, as the refugees may not have the proper tools or materials to maintain a complex hydroponic system.

We also took into account the extreme temperature ranges present in the desert. The temperature can range from 0 to 40 degrees Celsius. It was also realized that we should try to come up with a solution that can be assembled in or close to the camp out of local materials, possibly by refugees, to decrease the cost of the final product. Another important thing is that the hydroponics system should be designed to accommodate many different types of produce at the highest possible yield for the given area. The final design criterion that we were able to provide is that the hydroponics system should be easy to operate and not require much attention from the refugees to operate effectively. Table 1 below shows how our team of engineers ranked the design criteria.

TABLE 1: Displays the design criteria rating by importance.
Rating: 1 → least important, 5 → most important

Design Criteria Rating		
Need	Design Criteria	Importance
Durability	Can survive the harsh effects of sand storms	4
Amount of water required	Water efficient (L/day)	5
Needs to survive the temperatures	Can be used in any temperature without water loss and plants are protected from frost	3
Provide different produce	Can grow a variety of plants	3
Protect plants	Has to keep vermin away	2
Possible building materials	Could be built or assembled locally	4
Refugees do not have much money	Must be cheap (\$)	5
Electricity	Requires no electricity to function	5
People of differing backgrounds/professions are present in the camp	Easy/intuitive operating procedures	2
Needs to supply food to as many people as possible	Capable of providing enough food to help sustain a tent of 6 families	3
Efficiency	Does not require too much attention	2
Building material	Made from local material	1
No tools/ few materials	Easily assembled and maintained	3

Following the design criteria, the next step in the design process was to research existing designs and benchmark them appropriately. Our team of engineers researched four different designs shown in Table 2.

The Design 1 system researched was the Home Hydroponic Unit. This system was constructed out of stainless steel and has 3 growing trays for the plants. This system uses a drip method to simulate rain and requires nutrients to be added to the system. This system also requires 170 W of electricity to operate a pump to move the water nutrient solution and to operate the lights to simulate sunlight. This system would not be effective because it needs a constant supply of water and electricity to function and the plants would be exposed to the harsh elements without any protection.

Design 2 is a simple mechanism requiring a pot and a sponge to function. The foam sponge would be the medium for the plant to grow in and the polyethylene pot would hold the water. When benchmarking this system our team thought it was too small and would require too many units to obtain a sufficient amount of produce.

General Hydroponics manufactures another system that was benchmarked; the model is the Water Farm 8 pack (Design 3). This system uses a drip method to allow water to drip into a pail full of clay pellets. These clay pellets would absorb water and support the plants. We did not feel that this system would be adequate seeing it requires electricity along with large amounts of water to function.

The final design that we looked at was the Hydroponic System Site (Design 4). This design is quite simple; it is a series of PVC pipes with holes cut in with baskets placed inside to support the plants. The system works by pumping a water nutrient solution through the PVC pipes to ensure that the plants have adequate source of water and nutrients.

The full specifications and rankings of the attributes of each system can be found in Table 2 below.

TABLE 2: Specifications and benchmarking for existing hydroponic systems.
Rating: Green → Good, Yellow → Medium, Red → Poor

Existing Hydroponic System Benchmarking Table				
Design	Design #1 <i>Source: Home Hydroponic Unit</i>	Design #2 <i>Source: Ideahere Black Mesh Pot Net Basket</i>	Design #3 <i>Source: WaterFarm</i>	Design #4 <i>Source: Hydroponic Site Grow Kit</i>
Size (per Unit) Planting Area	188 cm x 132 cm	4.8 cm x not specified x not specified	62.3 cm x 62.3 cm x 62.3 cm	88.90 cm x 32.02 cm x 22.86 cm
Cost	Not Specified	\$ 5.25 CDN	\$ 558.71 CDN	\$ 155.00 CDN
Volume of Water (L) Required to Operate	100 L	Not Specified (very small)	79.2 L	15 – 20 L
Material	Stainless steel	Polyethylene w/ foam inserts	Plastic	PVC
Weight (kg)	80 kg	Not Specified	19.64 kg	11.84 kg
Electricity	170 W	N/A (no pump)	Yes	Yes
Water Consumption (L/day)	8 – 10 L/day	Not Specified	Not Specified	Not Specified
Medium	Water	Water	Water + Clay Pebbles	Water

2.4 Design Solutions

The next step in the design process was to come up with a conceptual design solution. Our team of engineers got together to brainstorm as many ideas as possible. After coming up with 12 possible designs, an evaluation was completed to determine the 3 designs that our team felt would solve the problem in the most efficient and effective manner. Figure 3 below shows a sketch of one of our conceptual designs. This design uses a drip method. It consists of an elevated reservoir tank with holes drilled in the bottom to allow the water and nutrient solution to drip onto the tray below that will hold the plants. The design would be constructed out of wood for the framing and plastic for the tanks and it would use sand as the growing medium. This solution was considered because it requires no electricity to function. The drawbacks of this design are that it is impossible to control the rate that the water flows and the plants will be shaded and may not get adequate sunlight due to the overhead reservoir.

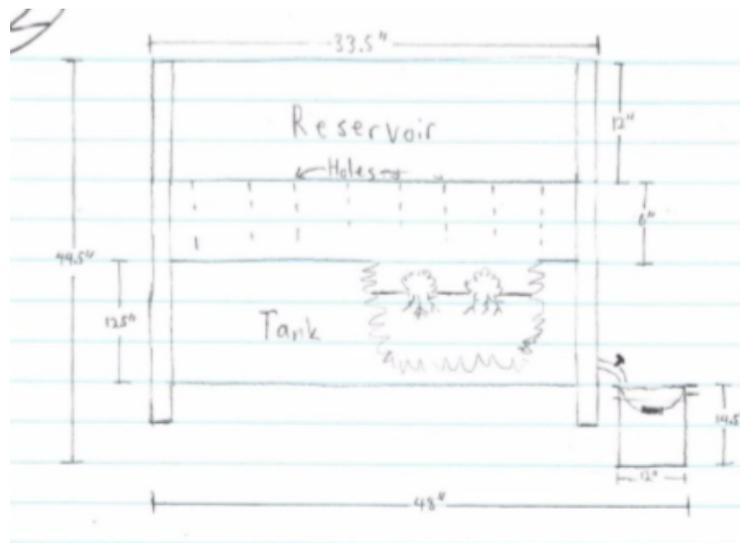


Figure 1: Conceptual Design 1

The second conceptual design our team of engineers were able to produce was more complex and required a hand pump to operate as displayed in Figure 2. This design would consist of a reservoir to hold the water nutrient solution which then would be pumped into a plastic tank. This plastic tank would have a fixed tray with pots in it to support the sand growing medium and the plants. The downfall of this design is that someone would have to constantly pump water through the system so the water does not become stagnant.

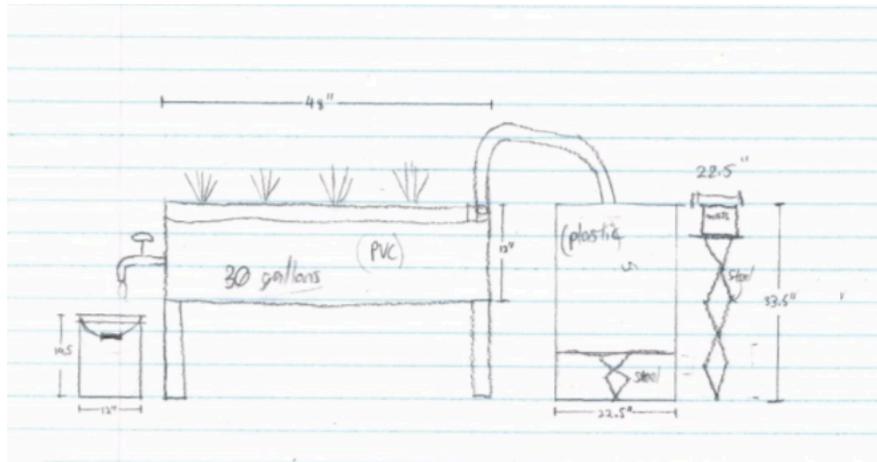


Figure 2: Conceptual Design 2

The final design that was selected ended up being the design that was prototyped. Design 3 shown below in Figure 3 consists of a plastic or steel drum with a volume of 170 litres to be cut in half and act as two tanks that will hold a water nutrient solution. The plants will sit in two styrofoam trays that will have holes cut in them and a screen attached to the bottom. The holes will be filled with sand and the seed will be placed in this sand which will support the plant as it grows. This system does not require electricity to function and allows for a constant flow of water at 19 litres per hour to ensure the water does not become stagnant. Once the water has moved through the system it is collected in a pail and is reused. A detailed drawing of this design can be seen below in Figure 3.

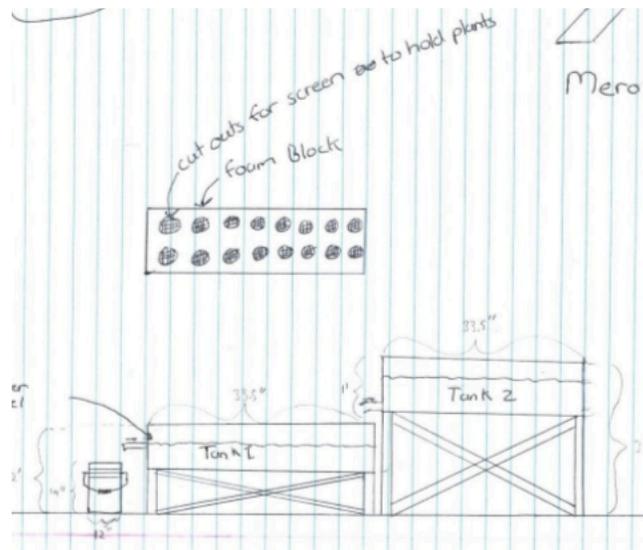


Figure 3: Conceptual Design 3

2.5 Prototypes

The next phase of the design process was to create prototypes of our selected design. The first prototype constructed was made out of cardboard as shown in Figure 4 below. The reason for the selection of this material is that it is cheap and easy to obtain. Although we were unable to perform tests with water, will still achieved our goals with this prototype which was to get a scale, three-dimensional representation of what the final prototype would look like. This prototype also allowed the concept of how it would work to be easily communicated to the customer to gain valuable feedback on what should be improved. The main concern the customer had was the large amount of water it would require (170L), also whether or not the materials would be durable enough. Another concern the customer had was seeing as the original design was open to the elements, the plants may get damaged by sandstorms, and water may be lost from evaporation. These concerns of the customer were addressed in later prototypes.



Figure 4: Prototype 1

The second prototype that was constructed was made from a 5 litre plastic pail as seen in Figure 5. This prototype was simple and was constructed as a proof of concept. It also allowed our team to visualize problems that may occur in the construction of our final prototype. Unfortunately, due to the budget and time constraints we were unable to construct the second prototype to the quality that it would need to be for tests to be performed. Our team was also unable to show our second prototype to the customer to obtain feedback.



Figure 5: Prototype 2

2.6 Final Design

The third and final prototype that was constructed was a representation of what the final product would look like. The prototype was constructed out of a plastic 170 L drum that was cut in half, styrofoam, screen, lumber, and cast aluminum taps as shown in Figure 6. This prototype was tested to see if it was possible to obtain a 19 L per hour flow. It was also tested to see how buoyant the styrofoam was. After performing the tests, it was shown that it is possible to achieve a rate of flow of 19 L per hour and that the styrofoam had a flotation capability of approximately 18 kg. We were also able to obtain feedback from the customer and specialists in the field of hydroponics. The feedback gained was very useful and would be considered in future developments of the product.



Figure 6: Final Design

The final design chosen as shown in Figure 6 was selected because it fit most of the original design criteria to meet the customer needs. The system may require a large amount of water to get started but once the system is filled it is very water efficient seeing as the water is constantly recycled through the system. The large amount of water present also allows the system to withstand large temperature variations because it takes a longer time to heat and cool. In addition, the larger volume of water will heat during the day and take longer to cool at night, providing an insulating factor for the plants during the night when temperature cools.

Our system was designed to be constructed out of material that is easy to work with, and found in and around the Jordan area for a relatively low price. Along with the materials being cost effective they are also very durable. This design was also selected for its simplicity. This feature is important because it means that almost anyone can assemble it right on site.

Our team also felt that this is the best design because it does not require any electricity to function. In addition, it does not require much attention to function while still allowing the plants to grow efficiently to obtain the highest possible yield.

The final design was designed and built focusing on simplicity. Looking at Figure 6 it can be seen that the design has two tanks that will hold a water nutrient solution. These tanks have taps in them that will allow the refugees to obtain the desired flow rate of 19 L/hr. The reason for the flow of water is to allow the water to move from one tank to the next to minimize the possibility of the water becoming stagnant allowing algae and parasites to grow. The flow of water is also important to keep the water aeriated so the plants roots do not drown. Once the water flows through the system it is collected in a bucket and recycled back through the system.

There is a styrofoam board with holes cut in it and a screen attached to the bottom to support the seeds and the growing medium. The growing medium the system is designed for is sand; the reason why sand was selected is because it is readily available. We decided to choose styrofoam for the material because it has tremendous buoyancy that will allow it to support the weight of the plants and it also allows its position in the tank to fluctuate as the water level changes.

A clear plexiglas cover for the two tanks will also be constructed to protect the plants from sandstorms and to minimize the amount of water lost due to evaporation. This cover will also allow the system to gain water from condensation that will occur due to the large temperature fluctuations.

3.0 CONCLUSION

In conclusion, our team successfully created a durable, functional hydroponics system prototype which could be used in a desert environment by refugees. The team managed to design the hydroponics system through the creation of a design criteria which ranked the criteria by importance as well as create target specifications through the use of benchmarking. After deciding on the target specifications, we proceeded to the third step of design thinking of ideation and created 12 different design concepts which were further narrowed down to 3 final ideas. Using the ideas, the group took the best aspects of each to design the first prototype. With the first prototype, our goal was to get feedback from the

customer regarding how it would fit their needs and get recommended improvements on the project. With the second prototype, we designed it to test the flow rate but due to constraints from scaling, the prototype did not yield any useful information and the ideal flow rate was subsequently calculated instead of tested. With the final prototype, by virtue of good planning, research, and accurate designs, a functional prototype was created without issue.

We began this project by developing a problem statement; “Syrian refugees need a sustainable source of food that is, water efficient, durable, does not require electricity and is cost effective with ease of use.” Despite the fact our project may not be the most innovative we strongly feel that it will reliably meet the needs of our intended users.

The design is large enough to support a variety of plants and yield a high amount of nutritious food because of the larger surface area for planting. We agree the initial amount of water required to get the system started may pose problems and this is an area that could be improved but the fact that beyond the initial water supply, it requires very little additional water to maintain the system. The volume of water provides additional benefits and the heating and cooling cycles will be an advantage. The larger volume of water will take longer to cool at night therefore provide warmth and protection for the plants during cool nights. As the water cools at night, because of the larger volume it will take longer to warm during the day, therefore reducing evaporation. Although the required initial water supply could be improved, the benefit it will provide somewhat minimizes this fact. The plexiglas lid will also act as protection for the plants at night and during sandstorms as well as take advantage of the temperature ranges to create condensation that will help sustain the water supply. The design is very durable and easy to use. It is made out of materials that can withstand the desert environment plus it is sturdy and heavy enough that it will not blow away in a storm. Beyond initial set up, the only maintenance this system requires is recycling the water back through the system. In addition, the system does not require electricity.

As a result of working on this prototype with multiple deadlines, the group learned many lessons including time management, communication, and planning. In regard to time management we learned to start deliverables and prototypes earlier in order to complete them in the given time in order to meet the multiple deadlines. Successful time management also increases the chance to add ideas to the next prototype as well as increase the build quality of them. Communication was important throughout the project and when we became aware of its importance we increased our efforts of informing everyone about every aspect of the project. This led to new ideas being sprouted ultimately making a better prototype.

Planning was an essential part of our project. For the first few deliverables they were last minute and the structure of the deliverables were not properly planned out. As the semester progressed, we planned out how every deliverable was to progress ahead of time to decrease the amount of wasted time and increasing the organization of the deliverables. For the future, deliverables should be started sooner, planning should always be the first and most important preparation step, and communication is key to creating a better product.

Although our product may not be the most innovative, it is practical and will work for the purpose intended while maintaining the integrity of the design criteria ranking. There is no doubt that the application it was intended for is of great importance. The

Syrian refugees have endured unimaginable hardships and any product that would alleviate the strain of survival that they experience on a daily basis needs to be the priority. With that in mind, our team created a solution that will meet their needs and allow each person to gain a sense of pride and accomplishment by being able to support some of their basic needs that have been so unfairly robbed from them.

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