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Jordan, Sustainable Food Supply for Refugee Camps in Jordan

Jordan Refugee Camps: Hydroponic Farming Solutions for Food Insecurity

Introduction

Across the world, thousands of people flee their homeland each year in search of a haven; a safe place for their families to call their own while conflict and crisis consume their birthplace. Jordan is a country that received a large influx of refugees crossing their borders over the last decade. As of the end of 2019, the number of refugees currently registered in the Hashemite Kingdom of Jordan stands at 744,795 with an in the Syrians' case, conflict. Eighty-three percent of the refugees live outside of designated refugee camps in the urban area of Jordan (United Nations Refugee Agency, 2019). A large proportion of refugees living both inside the camps and in urban settings have been experiencing food insecurity since their arrival (World Food Program, 2020). This insecurity pressure is influenced by the outbreak of COVID-19, reducing household market access and slightly increasing inflation for food products to 5.2% in March of 2020 (World Food Program, 2020). This paper proposes three solutions to address food insecurity for refuges in Jordan. If a solution is successful, it can be used at various refugee camps and isolated rural communities around the world to combat the food insecurity.

The total population of Jordan itself is estimated as of April 7th, 2021 at 10,280,336 with 91% of its population living in an urban setting and 8.9% living in a rural environment (Worldometer, 2021). Jordan's population is employed as follows: 22% in the government sector, 20% in finance, 18% in manufacturing, 10% in hospitality and tourism, 9% in transport, 5% in construction, 4% in ICT, 4% in services, 4% in agriculture, 3% in mining, and 1% in non-profit as of 2016. The unemployment rate in Jordan was 15.25% in 2016 (Economic Policy Council, 2018). Currently, Jordan is ruled by a constitutional monarchy according to the 1952 constitution (Library of Congress, 2006). The Hashemite Kingdom is politically stable; however, there are up and coming challenges that include: spillover from the Syrian civil war including refugees, stagnation in internal economic development, and religious extremism. As of 2019, Jordan's GDP is US $44.4 billion (World Bank Group, 2019). Jordan has a very arid climate; with little precipitation, only receiving rain in its short cool winters. Its geographic area can be divided into four areas; the Jordan River Valley in the west; the Highlands, east of the valley; the Plains, running north and south; and bordering the next region the Al-Badiah Desert region in the far east (Food and Agriculture Organization of the United Nations, 2008). The refugee camps that are of focus are located mostly in the Highlands area bordering the River Valley.

Shelter in Jordan camps usually consists of one or two room households, with the average refugee family unit outside the camp being 5.3 family members or people and in-camp family units being slightly smaller. Twenty-two percent of these households are led by women. (Tiltnes, Zhang, & Pedersen, 2019). Currently, the refugees' diets consist of traditional Arabic bread which is distributed for free, potatoes, rice, white flour, and legumes such as lentils for starches. Sometimes they can access fruits and vegetables such as onions, tomatoes, and garlic. They often do not eat the meat provided, as it is often frozen and expensive (Busquet, 2016). Refugees can get work permits; those in host communities make an average net income of JD 220 (approx. USD$ 310) a month and those in camps make an average of JD150 (approx. USD$211) (Tiltnes, Zhang, & Pedersen, 2019). Sixty-three percent, nearly two-thirds of

Syrian refugees, confirmed that they receive electronic vouchers from the World Food Program. The highest risk food insecure refugees receive JD20, those not as at risk receive JD10, and those at lowest risk receive no aid. Of these households, 17% sell some of the food that they buy with these vouchers to get cash (Tiltnes, Zhang, & Pedersen, 2019). There are a cumulative number of 165,000 work permits for Syrian refugees, accounting for 45% of the eligible working age population. These refugees are permitted to work in the agriculture, construction, hospitality, and the manufacturing industries (United Nations Refugee Agency, 2019). Refugees in these camps have minimal access to water, making proper sanitation difficult. People often must rely on store bought water to make up for the lack of water brought to these camps. Children from ages 6-11 have an almost 100% enrolment rate in schools in these camps, while 14-year-olds and 15-year-olds have a basic education enrollment of 68% and 48%, respectively (Tiltnes, Zhang, & Pedersen, 2019).

The average farm size in the Highlands is 20 hectares with farms near the Jordan river basin averaging only 3.5 hectares (Philippe, 2004). On Highland farms they grow cereal grains such as wheat and barley. Irrigated farms on the Jordan River Valley produce citrus fruit and vegetables such as potatoes, tomatoes, cucumbers and even olives (Irvine, 2021). Farming these lands can be exceedingly difficult with the water scarcity prevalent in Jordan; however, with the advancement of farming techniques including greenhouses and drip irrigation people are still able to produce food. Jordan imports up to 98% of food products including, barley, wheat, rice, sugar, powdered milk, corn, vegetable oil (not including olive oil), cheese, chickpeas, and lentils. (The International Trade Administration (ITA), U.S. Department of Commerce, 2020). Jordanian agricultural exports consist largely of fresh fruits, and vegetables; along with potassic, and calcium phosphate fertilizers (Observatory of Economic Complexity, 2019).

Food Insecurity In Jordanian Refugee Camps

With the agricultural production constraints that exist in Jordan there is already a restriction on food production. The addition of refugees fleeing from other countries increase this problem. The challenge that has emerged and now needs to be addressed is the issue of not having a sustainable food source at refugee camp locations to combat food insecurity. In refugee camps food security has worsened from 2019 to 2020. There was an increase in insufficient food consumption from 5% in 2019 to 19% in 2020 (World Food Program, 2020). Sixty-three percent of the households living in refugee camps are food insecure or at risk of food insecurity. Overall, it's estimated that in 2020 only 12% of households were food secure, 67% were vulnerable to food insecurity and 21% faced food insecurity in host communities (World Food Program, 2020). It is evident that Syrian refugees are suffering. This issue must be addressed.

While food insecurity was present before COVID-19, the pandemic demonstrated how easily supply lines can be disrupted and weakened. It displayed the need for a sustainable source of food in the refugee camps, instead of having to import all the needed supplies. Due to the economic downturn of COVID-19, people lost their jobs, a source of extra income. In 2020, 78% of households said they relied on the voucher given by the World Food Program to provide food (World Food Program, 2020). Combined with job losses, rising debt in refugee households, and needs in addition to food, you have a weakened chain waiting to break.

Traditional agricultural practices will not work in this case. This is largely due to the water crisis that has historically and is currently plaguing Jordan. Jordan is presently one of the most water stressed countries in the world (Garthwaite, 2021). This shortage of water limits the feasibility of setting up normal sustainable gardens. Not only will the water shortage stop refugees from growing their own food in these camps, but the arid climate will also contribute to the constraint on producing food.

Proposed Solutions

To address the issue of food insecurity in Jordan refugee camps, three potential options are proposed as potential solutions to face this challenge representing a range in cost and complexity. Hydroponics is a key component in each system; hydroponics is a method of growing plants in water without soil. Two of the solutions focus on vertical hydroponics, which is characterised by layering planters vertically, pumping water through a series of irrigation tubing and PVC piping to allow for a mineral water solution to reach the roots of the crops and grow them from there (Wilson, 2020). All three solutions utilize a complete off-grid renewable water and energy systems. These options will be composed of multiple interlinking components and are describe in the next paragraphs. The components and their cost for each solution are listed in Table 1. For option 1 and 2, there is a lower range cost and upper range cost.

Option 1 is the most expensive option, using the most technical and outsourced components. This system would utilize the following components: 40-foot shipping container, transparent tarping, solar panels, wooden frame, PVC pipes, irrigation tubing, four submersible pumps and Hydropanels, built by the company Source Global (Source Global, 2021). To allow for a more controlled environment, a shipping container would be needed in combination with both reflective and transparent tarping placed over the shipping containers modified open top. Inside would be four vertical farming units, each with it own submersible pump. The frame should be built of wood, plastic, or metal, whatever is readily available. The water needed for the units will be obtained through the Hydropanels. These Hydropanels have been engineered by Source to take moisture from the air and turn it into drinking water. The Hydropanels are powered by their own individual built in solar panels, While the rest of the power for the four 10-watt pumps would be gained through one solar panel. Nutrients would be applied to the water and then ran through the pump, to the irrigation tubing and through the PVC piping to reach the crops. The frame would play a key part as it is shaped in a triangular prism to allow for all plants to have equal access to sunlight. The frame will be 6 by 10 feet. Placed inside the unit will be twenty self-watering containers to grow heartier vegetables such as potatoes or carrots if possible. These planters will be featured more prominently in option 3. The cost of option 1 is the biggest hurdle to over come to reach as many refugee families as possible.

The second option will be much like option 1, except that the previously mentioned Hydropanels will be swapped out for a two dehumidifier that would be run via solar panels (Table 1). Instead of one solar panel, five will be needed to operate the dehumidifiers. While sounding expensive it is still less then purchasing two Hydropanels. Two Hydropanels have a retail cost of $6000.00 USD while the two dehumidifiers and the solar panels needed to run them cost $914.59 USD. The shipping containers and tarps would still be utilized in the same manner, optimising crop production. The hydroponics units would be the same, a triangular prism frame using irrigation tubing, PVC piping and submersible pumps to keep them running. The self-watering planters would once again be utilized but not the focus. This is the medium option. It requires technical knowledge and greater collaboration with stakeholders. Although costs have been reduced it may still be a barrier in assisting as many refugee families as possible.

The most inexpensive of the solutions is an outdoor hydroponic solution (Table 1). Self watering hydroponics pails will be used with frames and tarps. For this solution fifty 5-gallon pails would be used instead of the twenty that would be utilized in the second and third solutions. That would allow fifty self watering planters with three net pots in each planter. Of course, these planters would have to be started with the water-nutrient mix and topped off from then on. The water would be obtained using dehumidifiers powered by solar panels. The data estimated in table 1 has five solar panels, the dehumidifier used takes approximately 180 watts. Using reflective tarps, shade would be provided to protect from the plant withering heat. This approach is simple and mostly requires human labor to develop a system that works in the Jordanian climate. However, the lack of a permanent structure may make reduced the security of the hydroponic farm. While the most inexpensive of all three options there is limited ability to control the growing environment and this system is not easily portable if the need for food at the refugee camp ended. It would take more physical labor; however, this unit requires less technical knowledge. The Outdoor Hydroponic unit is a viable option to face food insecurity in Jordan refugee camps.

Components For Hydroponic Crop Production Systems

Shipping Containers

The shipping containers will be used as a structure for these vertical farms. The shipping containers should be relatively easy to procure with used containers costing around $3000.00 to $6000.00 USD. The steel ceiling of these containers would be cut-out and replaced with a transparent material either glass (more expensive or transparent tarp) to let natural light in. Modification could be accomplished with simple tools. The solar panels will be near the container to stay connected to the unit for power supply. Research would need to be done on the best combination of shade provided by reflective tarps in the mid day, so the plants will not wilt. If these units are no longer needed for food production at the current location, the shipping containers make it convenient to transport the vertical hydroponics farming systems to where they are needed.

Vertical Hydroponic Farming

The vertical farming system we would use should be comprised of many segments. The submersible pump, which will be powered by solar energy will allow for the hydroponics system to run. Using irrigation tubing the water will move up to the top of the triangular prism frame and from there gravity will run the rest of the hydroponics system by distributing the water down through a system of irrigation tubing and PVC piping. The frame would be made from available wood, plastic, or even metal. Depending on the crop being grown the frame can have four to six levels of PVC piping providing the space needed for plant development. PVC piping will act as holders for the net pots, where the plants will be placed allowing for the roots to access the water-mineral solution.

Solar Panels and Batteries

Solar Panels are a renewable way to power the other components in this system. These solar panels when under optimal conditions can convert 22% of solar energy into usable energy (Vourvoulias, 2021). The panels suggested are 100-watt panels however it is suggested that collaboration between electrical engineers and system engineers develop the finer details when it comes to energy output and load. The cost of these solar panels will depend on the energy demand of the equipment used and how much the cost of solar panels decreases over the near term. Batteries for nighttime operation will also need to be included in the design. To incorporate energy from the solar panels an inverter and charge controller is needed to finish implementing the system.

Hydropanel and Dehumidifier

Hydropanel produced by Source Global can pull up to five gallons a day from varied humid air. They run independently of any power source, supplemented by their own built in solar panel (Source Global, 2021). The specified dehumidifiers can pull up to four liters at a given time. It may be more complicated to power the dehumidifiers however as there would need to be a solar power grid built in the area.

Reflective Tarping

These tarps can serve two purposes, bringing in dusk and dawn light by angling them in the right manner and they can also serve as shade in the hot mid-day, so the plants do not wilt.

Self Watering Planter

Self watering hydroponic planters often referred to as the Kratky System use one pail of any verity with a lid, a net pot, and growing material (Espiritu, 2019). In this method the reservoir needs to be filled so that it covers a third of the net pot. The water will need to be treated with all the nutrients a plant will need for growth. As time passes the root system will develop sucking up the water providing air in the reservoir for further growth.

Crop Options and Environmental Conditions

We would need to research and carefully consider what environment each crop is best suited in to maximize production in these units. There should be a focus on growing crops such as, tomatoes, cucumbers, basil, strawberries, and lettuce along with other leafy greens to start with. If possible, research should be done into the possibility of growing more calory ridden vegetables and fruits, such as potatoes and even squash, with hydroponics to provide a range of nutrition.

Funding

Funding for these solutions could be a problem. If option 1 is used it would be expensive however, Source Global, the producer of the Hydropanels already has drinking water projects in place in Jordan and other countries in the middle east. They may be willing to do a collaboration with an agency such as the UNHCR (United Nations High Commissioner for Refugees) to bring this solution to light. Another option would be to utilize the UNHCR's innovation fund if this idea is approved (UNHCR, 20201). The innovation fund provides teams with funding and support for teams within the UNHCR. They could be willing to collaborate with a team and fund this project.

In-kind funding may be obtained by working with engineering programs at Universities. Professors may be willing to further the development of these solutions by assigning the design of the different components as class projects. In addition, High School classes might also be interested in such a project if enough exposure is produced. If a school does a hydroponics project, they can also campaign to raise funds for building additional hydroponic systems for refugee camps. From there, other schools may also gain interest in such a project and be inclined to participate as well.

Table 1. Three Hydroponic Vertical Farming Setups with Equipment and Estimated Costs

Equipment	Option 1. Container With Off The Shelf Components		Option 2. Container With Fabricated Components		Option 3. Outdoor Hydroponic Unit
	Lower Range Cost	Upper Range Cost	Lower Range Cost	Upper Range Cost	
Shipping Container (used 40 feet)	$3,000.00	$5,000.00	$3,000.00	$5,000.00	$0.00
Transparent Tarp (four, 4 feet 8 feet by 10 feet)	$539.84	$640.00	$539.84	$640.00	$0.00
Reflective Tarp (two, 3 by 4 meter)	$108.64	$108.64	$108.64	$108.64	$108.64
Hydropanels (set of two)	$4,000.00	$6,000.00	$0.00	$0.00	$0.00
Dehumidifier (two 12 litre, 180 watts)	$0.00	$0.00	$364.64	$364.64	$364.64
Solar Panels (100 amps) [a]	$110	$110	$549.95	$549.95	$549.95
Charge Controller (10 amps)	$29.99	$29.99	$29.99	$29.99	$29.99
Inverter (1000 watt)	$101.00	$189.99	$101.00	$189.99	$101.00
Lithium Iron Battery (12 volt, 40 amps per hour)	$358.90	$358.90	$358.90	$358.90	$358.90
Submersible Pump (four, 100 gph- 150 gph, 10- 26.5 watts	$64.80	$75.80	$64.80	$75.80	$0.00
PVC Pipe (3-inch 320 feet)	$656.00	$1,801.60	$656.00	$1,801.60	$0.00
PVC Pipe End Cap (3-inch 64 caps)	$235.52	$235.52	$235.52	$235.52	$0.00
Irrigation Tube (100 feet)	$13.93	$14.55	$13.93	$14.55	$0.00
Net Potts (2-inch 50 set)	$98.99	$98.91	$98.99	$98.91	$26.97
Wood Planks (2 by 4 inches by 10 feet, 48 Planks)	$671.52	$671.52	$671.52	$671.52	$279.80
5 Gallon Pail with Lids [b]	$131.00	$131.00	$131.00	$131.00	$327.50
Total Cost Without Shipping	$10,120.12	$15,466.41	$6,924.72	$10,271.01	$2,147.39

[a] One Solar Panel is required when Hydropanels are used, five Solar Panels are required when dehumidifiers are used and, five Solar Panels are required when running the Outdoor Hydroponic Unit.

[b] Twenty pails will be used with both option 1 and 2, fifty pails will be used in the Outdoor Hydroponic Unit

Implementation of Solutions

For any of these solutions to work, there would need to be a collaboration between an engineering team, agronomists, locals, and refugees. The engineering team would need to optimize equipment operation and to provide more accessible and inexpensive technologies. Agronomists and experts in the hydroponic field would need to collaborate to facilitate crop production and then work with the engineers to achieve the appropriate growing conditions. Once a low technology system is implemented this knowledge and ability would need to be transferred to local farmers and refugees to ensure the successful operation of these new systems. Some of these experts should be sent to Jordan to display the benefits of these options to the refugee community and convince them to operate these units. Localized shipping containers would be utilized and modified on site where these units are to be built with locally hired labor or a refugee effort.

This solution would not meet all the needs in refugee camps and host communities. It is estimated that one unit could feed two to six families. It would increase their food security by allowing part of the community to be self reliant and address some of their needs for healthy nutritious food by providing fresh, healthy vegetables. It would provide technical experience on this type of operation for farmers, and it could contribute to potential growth of private agriculture and expansion of different food products in the Jordan markets. It could possibly have a positive psychological boost on refugees and raise morale as they would be growing their own food and not relying on foreign aid. These systems would allow for most age groups to participate, facilitating youths to develop potential work skills. It could increase confidence in the older generation as the work is not taxing and will allow them to help provide for their family unit. It may even increase social cohesion within the family.

The challenges to consider when implementing any of these solutions is the cost, the labor, and the knowledge and research that is needed to develop this project. Finding an organization to manage, expand, and handle the outreach of this project could be difficult. Research will need to be done on the calibration of the solar panels to maximize environmental controls. Teams would need to develop a better understanding of crop growth patterns with different control environments and find the outcome that will allow for maximum crop production. Procuring an effective way to ship these components safely and cost effectively to Jordan may be challenging. These challenges will require more research and development.

Once designed units can easily be deployed in other scenarios where food security is put at risk. Aid groups can ship these units to remote communities that might have a hard time getting regular access to fresh produce. We have seen shipping containers turned into vertical hydroponic farms by the company Growcer. They modified shipping containers to withstand temperatures between -50 and 50 degrees Celsius while still function as a hydroponic farm (The Growcer Inc., 2021, https://www.thegrowcer.ca/growing-systems). The Growcer unit, however, is made from expensive material and sold at a high cost for commercial use; for this project to be successful the unit components would have to be built from inexpensive and locally available supplies.

Conclusions

In conclusion, the Syrian refugees living in Jordan are facing food insecurity. The solutions proposed in this paper use self-sufficient food production systems to create sustainable food sources that can be placed near refugee camps to alleviate food insecurity within them. This will substantially improve quality of life for these refugees as they live away from their homeland. If successful, this solution could be utilized at many refugee camps and isolated rural communities that are faced with food insecurity. For this project to succeed there will need to be an investment in engineering and agronomic solutions to develop the needed knowledge and cut down on costs involved with this project.

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