AMERICAN UNIVERSITY OF BEIRUT

HYDROPONIC AGRICULTURE IN LEBANON: A WINDOW FOR FOOD SECURITY AND RURAL DEVELOPMENT

by
RONA FADI HADDAD

A project
submitted in partial fulfillment of the requirements
for the degree of Master of Science
in Rural Community Development Program
of the Faculty of Agricultural and Food Sciences
at the American University of Beirut

Beirut, Lebanon
May 2021

AMERICAN UNIVERSITY OF BEIRUT

HYDROPONIC AGRICULTURE IN LEBANON: A WINDOW FOR FOOD SECURITY AND RURAL DEVELOPMENT

by

RONA FADI HADDAD

Approved by:

Dr. Mabelle Chedid — Advisor
Research Associate, FAFS

Dr. Shady Hamadeh — Committee Member
Professor, FAFS

Date of project presentation: May 10, 2021

AMERICAN UNIVERSITY OF BEIRUT

THESIS RELEASE FORM

Student Name: _____Haddad_____Rona_____Fadi_____
Last First Middle

I authorize the American University of Beirut, to: (a) reproduce hard or electronic copies of my thesis; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes:

☒ As of the date of submission

☐ One year from the date of submission of my thesis.

☐ Two years from the date of submission of my thesis.

☐ Three years from the date of submission of my thesis.

(to check a box above, right click on the box, choose properties, then select "checked". DELETE THIS WHEN DONE)

Signature

23/08/2021
Date

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to my advisor Dr. Mabelle Chedid, for supporting me and guiding me along the way and for her constructive comments that helped me improve the quality of my project.

My gratitude is addressed to Dr. Giuliano Martiniello for being a great professor in all the Rural Development courses throughout the past two years and for introducing me to the interesting and challenging topic in Rural Development and for his continuous and professional support whenever I needed help.

My recognition is addressed to Dr. Shady Hamadeh and Dr. Ali Chalak, for providing insights and expertise that greatly assisted my research.

And finally, I would like to thank Mrs. Diana Abi Said for her assistance, encouragement, and support during the past two years whenever I needed anything.

ABSTRACT
OF THE PROJECT OF

Rona Fadi Haddad for Master of Science
Major: Rural Community Development Program

Title: Hydroponic Agriculture in Lebanon: A Window for Food Security and Rural Development

The following dissertation discusses the dire consequences of food insecurity in Lebanon while developing an agricultural solution based on the technical advancements of hydroponic systems. Lebanon is the perfect place for such development. The environmental, political, social, and economic conditions are often translated to limited farming and agricultural opportunities, but with hydroponic techniques, the planting, sustainability, and maintainability of agricultural crops can be introduced. Hydroponics supports the development of rural areas where their local economies are currently dominated by agriculture. Hydroponics has a substantial positive impact on rural areas in terms of decreasing rural migration, enhancing the farmer's business models, boosting agritourism, improving local economies and infrastructure, and lastly, developing the farmers' skills for more efficient agriculture practices. Hydroponic farming has been successful in several MENA countries, such as Jordan and Algeria, and since Lebanon has a similar context it could be adopted as well. The process of hydroponic farming will support the development and growth of the Lebanese farming and agricultural sector, pushing Lebanon out of its current status of being food insecure.

TABLE OF CONTENTS

ILLUSTRATIONS

Figure

CHAPTER 1

INTRODUCTION

"Rural development is generally defined as an overall improvement in the economic and social well-being of rural residents and the institutional and physical environment in which they live" (Jansma *et al.*, 1981). Most of the developing countries rely on rural areas for their survival and development resources. Agriculture is the main activity in rural areas and employs most of the working population. Moreover, rural populations ensure food consumption from agriculture production, hence ensuring household food security (World Bank, 2007).

The current political, economic, and financial situation in Lebanon has led to skyrocketing of food prices, Lebanese have become anxious and food insecure. According to a study by ESCWA, half of the population suffers from the inability to access food, as well as a third of the population is unable to maintain a healthy diet due to the inaccessibility of food (Awwad, 2020). The World Bank estimates that 45% of the Lebanese population sliding into poverty as a result of the economic and COVID-19 crises, with around one million people already living below the poverty line (The World Bank, 2020). A recent WFP survey found that food has become a major source of concern, with 50% of Lebanese respondents saying over the past month they felt worried they would not have enough food to eat (United Nations World Food Programme, 2020).

Agriculture activities in rural areas are at the heart of addressing the problem of food security and developing the lives of rural inhabitants to create sustainable agriculture output. Planting fruits and vegetables generate economic development and

create a greater income for farmers, and promotes food security at the household level, and by translation at the community and country level (Verner *et al.,* 2017). Hydroponic farming is a technique for growing plants in nutrient solutions such as water and fertilizers, with or without an inert medium like composted bark, pumice, and coco peat (coco coir or coco fiber) to provide mechanical support (Verner *et al.,* 2017). The hydroponic technique can be custom designed to be a low cost solution, affordable, and appropriate for small farmers in the rural areas. As the agriculture sector has been facing significant setbacks in Lebanon, this paper aims at discussing the innovation of hydroponic techniques to enhance the agriculture sector efficiencies in rural areas, and help in addressing the food insecurity problem of Lebanon, as well as support the rural development in the country.

Having briefly introduced the background and context surrounding the research problem, it is important to introduce the research questions that will be analysed throughout the paper. There are three guiding research questions this study aims to address:

The main question is:

1. How can the introduction of hydroponic, as an innovation in agriculture, enhance rural development by supporting the agriculture sector as well as enhancing the food sovereignty and security situation in Lebanon?

The two sub-questions are as follows:

1. How can hydroponic agriculture pave the way for significant rural development?

2. What are the major challenges for food sovereignty in Lebanon, especially after the economic crisis, COVID-19 pandemic, and 4th of August blast? And how can Hydroponics' impact on rural areas help address these challenges?

These research questions are integral to the wider research on food sovereignty in developing countries and make way for the introduction and examination of existing and potential hydroponic food security models in Lebanon. The following chapter will survey the existing literature on the topic, and cover different examples, definitions, and insights.

CHAPTER 2

LITERATURE REVIEW

2.1. Food Sovereignty and Security

2.1.1. Overview of Food Sovereignty and Security

Nowadays, food sovereignty and food security are getting more and more attention globally from researchers, policymakers, and even ordinary citizens who are involved in their country's affairs. Some existing studies in the broader literature have discussed the difference between food sovereignty and food security and how they should be distinguished from one another (Change for Children Learn & Teach Food Sovereignty, 2017). As seen in Leventon and Laudan (2017), food security can be defined as the status "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food, which meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). However, food sovereignty is defined by "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (La Via Campesina, 2007). Therefore, food sovereignty is a local movement that aims to achieve food security alongside maintaining wider values such as sustainability, ecological security, and human rights. Chaifetz and Jagger (2014) defined food security as a global policy that is concerned with food availability, access, utilization, and stability. Food sovereignty is mainly concerned with food availability. A critical part of food sovereignty is the availability of food and the means for food production for all people.

However, food access, which refers to the affordability of food in the market, has not been tackled yet by food sovereignty movements or ideals. That is because these movements have not been able yet to infiltrate the food industry and market to be able to control affordability and access. Moreover, food sovereignty debates usually do not give much attention to food safety and utilization. According to Desmarais (2008), food sovereignty movements have not set common or clear guides on food safety, other than eliminating genetic food modifications and avoiding low-quality food. When it comes to food stability, which is also related to environmental stability, this factor is one of the most essential components of food sovereignty. In fact, according to Altieri (2009), Alteiri *et al*., (2012), and Patel (2005), food sovereignty aims to achieve efficient farming systems and food production mechanisms that ensure sustainability and resilience to climate change (Chaifetz & Jagger, 2014). Therefore, food security is more of a policy that aims to ensure food for everyone, while food sovereignty is more of a political and social movement. This movement aims to achieve social-economic justice, fight hunger, promote local control of food production, support small scale producers, and build sustainable and ecologically appropriate food systems.

2.1.2. Challenges of Food Sovereignty

Today, researchers from around the world have recently attempted to raise more awareness about the concept by contributing to the food sovereignty debate and pushing readers to think more critically about it. Edelman *et al.*, (2014) conducted a review to delve deeper into food sovereignty as a dynamic process by assessing its relation to different rights movements, understanding the roles of states and markets in it, and considering the challenges that face its implementation. The authors start by

questioning the possibility of joining millions of small farmers that usually produce goods or offer services for export into one food sovereignty model. One of the factors that render its implementation difficult, or even sometimes impossible, to achieve is related to administrative and logistical issues. For example, if a united model was indeed achievable, who will be responsible for administering it? Is it the state or the market? The authors point out that food sovereignty movements should allocate more attention to this question if the implementation of sovereignty is to be effective. The main issue is that advocates of food sovereignty have always focused on the humanitarian, social, and political aspects of the concept but have not looked enough into its logistical and administrative aspects.

Another challenge that faces the implementation of food sovereignty is that with the rise of dependence on industrial food surpluses and the change in diets small scale farming is becoming less and less viable. In fact, it is still doubtful whether agroecological production would be able to feed a growing global population or not. Because, not only is the current population growing, but it is also becoming directed towards processed food and meat-based diets rather than cereals and vegetables, whether if it was out of preference, need, or purchasing power. The authors question whether local farmers and food producers would be able to keep up with the citizens' demands and preferences. Finally, Edelman *et al.,* (2014) state that, to overcome food deficits and achieve better self-sufficiency, the main priority should be a redistributive land reform combined with more public investments in small local productions (Edelman *et al.*, 2014). In a more recent study that was also conducted by Edelman (2014), the researcher stresses again on the fact that food sovereignty is not as simple as it may seem. He states that not only are food sovereignty advocates neglecting the

logistical and administrative aspects of the issue, but they also rarely tackle the economic and legal challenges that face it (Edelman, 2014). Food sovereignty movements should focus more on the role of long-distance trade in food sovereignty models and the application of relevant legal norms.

2.1.3. Case Study of Food Sovereignty in Italy

If Lebanon wants to be a food sovereignty country, it could adopt the below case study by examining the opportunities and learning from the challenges they faced. Below is a sample case study of an area in Italy called Umbria, and how they planned to implement food sovereignty and the steps involved. It is important to note that support from the Lebanese government is required, in addition to everyone involved in the agri-food system.

To address the planning and administration issues behind food sovereignty, several studies have examined the possible solutions that could be implemented to achieve a successful national food sovereignty plan. In 2019, Stella *et al*., reported a case study in Italy, Umbria, in an attempt to develop a Decision Support System (DSS) to achieve food sovereignty plans in the area. The DSS includes three main principles: the promotion of relocation of production and trade through adequate policies, the promotion of the protection of local identity, biodiversity, and agroecological farming, and the engagement of local communities in the development of food policies. To do that, they used three tools to first, calculate the land required to provide the food needed for the local community, second, implement land suitability maps for each plant involved in the diet, and third, calculate a Food Self-Sufficiency Index that portrays the

country's maximum achievable agronomic food sufficiency. The researchers then explained the underlying value of the developed DSS in achieving a National Plan of Food Sovereignty. Once the situation of the agri-food system is examined and evaluated, local authorities (municipalities and unions of municipalities) should organize a meeting that includes the inhabitants, landowners, farmers, food processors, food distributors, and local representatives of local food-business organizations; in other words, everyone involved in the agri-food system should be included in the process. Once the first phase of the process, which consists of several meetings and debates, is over, workshops should be conducted to promote commercial agreements between stakeholders and create development projects. The third phase consists of each local authority producing a draft version of its "Plan for Local Food Sovereignty" that summarizes its suggestions, agreements, and projects. Finally, at a regional level, all "Plans for Local Food Sovereignty" should be merged in an attempt to reach a final participatory process on a national scale. Local or regional efforts could allow countries to build a solid national food sovereignty plan that is based on the participation and cooperation of the whole population while minimizing the logistical and administrative issues involved with it (Stella *et al.,* 2019).

2.1.4. Food Security and Sovereignty in Lebanon

It is important to give some context to the larger situation in Lebanon. Indeed, food insecurity is not only a challenge in Lebanon, but as mentioned above, it is a global challenge and particularly in the MENA region with reports that point towards it being the most food insecure in the world (Jomaa *et al.,* 2017). With the recent Arab Uprisings, commonly known as the Arab Spring, food insecurity has become an

extremely serious challenge that goes on to threaten the ability of a given nation to provide food to certain people as a basic human right. In Lebanon, for instance, which is considered as a middle income country with an extremely fragile political, social, and economic system that plays a role in the increase of its food insecurity, has recently - and ever since the repercussions of the Arab Spring and the Syrian War - been continuously suffering as a result of its lack of food capabilities and many other issues that threaten its social fabric as well as its agricultural capabilities (Awwad, 2020).

Lebanon imports around 85% of the food consumed, and with the damage of the port of Beirut, which is the largest port in Lebanon, food prices increased drastically (United Nations World Food Programme, 2020). As an alternative, shipments were coming through the port in Tripoli, which is the second port in Lebanon. However, Tripoli's port is smaller and therefore less capable of handling shipments compared to Beirut's port. This disrupted the food supply chain in Lebanon, especially in Beirut. These events happened during a very difficult time in Lebanon with soaring unemployment rates and salary cuts with many families struggling to make ends meet.

Another factor that challenged the presence of food security and the implementation of food sovereignty was the port of Beirut blast that happened on the 4th of August 2020. The Tahrir Institute for Middle East Policy published a study by Kareem Chehayeb to investigate the food security situation in Lebanon post-blast. It was reported that the only grain silo with a capacity of 120,000 tons was destroyed by the 4th of August explosion, which worsened the food crisis in Lebanon. In addition to that, the local wheat production for bread only satisfies about 10% of the demand (Chehayeb, 2020). This limited local production, combined with the destruction of the grain silo, led Lebanon to import 80,000 tons of wheat in 2020, something that

happened for the first time in six years. For example, in addition to the wheat that was lost due to the blast, 24,000 tons of corn and 7,000 tons of soy were also lost (Sewell, 2020). Since corn and soy are a major form of feed for chickens, the prices of poultry have increased, and are also prone to increase even more.

He stated that short term responses, such as that of the World Food Programme that delivered shipments of food parcels for affected families, were important to alleviate the crisis. However, more serious long-term solutions and regulations need to be done by the government. In fact, due to the coronavirus pandemic, economic crisis, and Beirut blast, many farmers were not able to buy imported supplies such as seeds, chemicals, and fertilizers which are essential for planting (Chehayeb, 2020). Sewel stated that, if the crisis continued, agricultural production is predicted to decrease by 60 to 70% in the upcoming years. Not only will the farming production and industry be affected, but other food industries too. It was concluded that these issues make food sovereignty far from being implementable; but on the contrary, it is more likely that Lebanon will have to turn to international aid to stop hunger (Sewell, 2020).

Even before the port explosion, the food security situation in Lebanon was a major concern and was worsening. The dramatic economic and fiscal crises, hyperinflation, and rising prices had devastating effects on the economic vulnerabilities of the Lebanese populations. Many people lost their jobs and livelihood which were their means for survival. Therefore, many people in Lebanon do not have a source of income, which will affect their purchasing power and accessibility to safe and nutritious food. Hence, food security was negatively impacted.

With the rise of the COVID-19 pandemic, some key food producing countries, such as Romania, started limiting or even banning exports to some countries. Since Lebanon heavily relies on imports, its market is very vulnerable to some disruptions in the global trade (Wood *et al.*, 2020). As a result of all these factors, combined with the current exchange rate and currency shortage, imports have also become much more expensive, which is making it harder for the Lebanese citizens and inhabitants to secure enough food on their tables. In the case that some of them were able to secure food, the quality and safety of this food might be questionable.

Moving to the case of food sovereignty in Lebanon, several studies and reviews have been conducted to assess the possibility and challenges of its implementation. ESCWA conducted a study in 2016 aimed to investigate the gaps that exist in Lebanon in the context of achieving the Agenda 2030 and the SDGs set by the UN, specifically the second SDG which is related to food security. The empirical research took place over six weeks (March till April 2016). The primary data collection process consisted of 30 in-depth interviews with local experts, government officials, UN staff members, and other stakeholders related to food security. The secondary data collection process consisted of analysing and reviewing the set of academic, journalistic, and developmental literature related to the topic.

It has been shown in the study that 65 to 80% of Lebanon's food needs are imported which makes the country a 'consumer market'. The agricultural sector has been also neglected in Lebanon as it was estimated that it only makes around four percent of the GDP today, while it used to make 23% of it in the 1980s. Import dependency for essential food goods, such as cereal, vegetable oil, coffee, sugar, wheat, rice, and tea, is high, reaching 76 to 99%. Locally produced foods suffer from the

competition with internal imported goods; not only that but these local products only reach Lebanese markets through small market actors who do not benefit from economies of scale. In fact, that is mainly because Lebanon still lacks key market reforms related to free trade, regulating competition, intellectual property, and others. Moreover, logistical issues remain the main barrier against efficient food supply. Beirut's seaport and airport are the only routes for mass trade of food in Lebanon which makes this process in danger if any of the two ports closes. Even though the port of Beirut suffers from low operational and logistical efficiency and high corruption, it makes up to 73% of the total import capacity. In 2016, it has been shown that the port needs to be expanded by around 1.4 square kilometres to keep up with Lebanon's import needs. However, due to legal disagreements and political tensions between port operators and transport syndicates, the plan was never executed (Halabi & Ghanem, 2016).

Another similar report was conducted by Hwalla and Bahn in 2015. Their report was part of the American University of Beirut's efforts to tackle the issue of food security in Lebanon through developing methods to measure and assess food security, conducting research to examine its determinants, and launching programs to prepare students, change leaders, and policymakers to address it. According to report, even though most Lebanese citizens have access to food, clean water, and safe sanitation systems, some of them, in addition to most of the Syrian and Palestinian refugees living in the country, are still unable to utilize food properly. The main hurdle in achieving food security and sovereignty is the lack of data to assess the situation, collect needed information, design intervention plans, monitor their impact, and evaluate their results and success. Food security should not only be measured by limited indicators such as

food imports, but more in-depth studies should be conducted. To assess food security and sovereignty, the two researchers suggest that new tools should be developed so that they are culturally sensitive and able to assess the Lebanese situation specifically (Hwalla & Bahn, 2015). Some of the main issues behind the food sovereignty policies were showcased in a study by Babar and Kamrava (2010). In their paper, they analyzed the food security and sovereignty policies in two Middle Eastern countries, which are Lebanon and Jordan, and evaluated their efficiency during the 2007-2008 global food crisis. First, it was seen that the food production, namely the cereal production, is inefficient and insufficient in both countries. Second, the researchers found that, specifically in Lebanon, the government and policymakers are more concerned with power and control and less with the food security of their people (Babar & Kamrava, 2010).

Household food insecurity can, in a completely adverse way, affect the nutritional and health status of groups that are considered at risk, this goes in particular to women that are of a certain reproductive age (Jomaa *et al.,* 2017). At the same time, it is noted through recent studies that mothers living in food insecure households are considered to be at a higher risk of maintaining an inadequate dietary intake and are more likely to adopt negative and risky coping mechanisms, which include the limiting of food intake and simultaneously compromising the quality of their diets, to make sure that their children are properly fed. This is to note that food shortages and food insecurity can have social, economic, political, and industrial consequences. For instance, it is noteworthy to elaborate on the fact that low food security not only reduces the quality and the diversity of the mother's diets but can also lead to certain compromises which impact their nutritional status as well as towards leading

deficiencies in certain micronutrients. In addition to all this, food insecurity has also been associated with poor pregnancy outcomes; these include preterm births, low infant birth weight, and gestational diabetes (McIntyre *et al.*, 2003).

2.2. Hydroponics as an Opportunity for Food Security

Hydroponics generates a greater yield in production by using fewer water resources compared to traditional farming, making it a great solution to enhancing food security, particularly in developing countries (Verner *et al.*, 2017). The focus of this section is on innovation in the agriculture sector, particularly hydroponics, as the main force for improving food security in the country. By eliminating the soil and housing the roots directly into the water, the crops grown hydroponically flourished and were more efficient in growing (Hydroponic System Basics: The Ultimate Guide for 2021, 2021).

Based on recent statistics and studies, it has been shown that, although the Lebanese agricultural sector provides jobs for 25% of the national labor force, it only accounts for three percent of the annual economic growth (Wood *et al.*, 2020). They tried to identify the different factors that might be the reasons behind the deterioration of the agricultural sector. First, due to the lack of investments in this sector and the weak bargaining power of farmers against wholesalers and retailers, imported foods have always had a competitive advantage over local goods. Second, Lebanon suffers from poor infrastructure and low competition, which make local products more expensive, and therefore less desirable, than imports. Third, due to the lack of competition and consumer protection laws, almost all food industries in Lebanon are

managed by a few traders and retailers, giving them the power to control the prices and supplies (Wood *et al.,* 2020).

Hydroponics can help farmers and individuals to meet their need for a reliable source of quality food and sufficient resources to produce or purchase it. This, in turn, supports food security at the household level, and by translation, at the community and country level. By adopting hydroponic systems, agriculture productivity increases with the same amount of time. Larger volumes of produce can feed more people or can be sold to other different markets, resulting in an increase in the producers' and sellers' disposable income for purchasing capacity.

2.3. Case Studies of Hydroponics in MENA region

2.3.1. USAID Hydroponic Green Farming Initiative (HGFI)

USAID has implemented a hydroponic green farming initiative project in Jordan for the duration of three years. USAID's rationale for implementing hydroponic farming is to solve the issue of water scarcity that was affecting all lines of work in Jordan. Especially the agricultural sector that is consuming 65% of Jordan's water supply while only contributing to 2.5% of the GDP (USAID, 2017).

The Hydroponic Green Farming Initiative (HDFI) significantly improved the water efficiency in agriculture compared to conventional farming methods. As well as maximized the value of land by increasing the quantity of the agricultural output, the value of produce, and strengthened productivity. To elaborate further, the HGFI reduced the water consumption and land space used. For instance, the expected outputs with a land size of about 300 square meters of greenhouse produced 29,000 heads of lettuce,

using 216 metric cubes of water per year. However, producing the same quantity of lettuce, 29,000 heads, through traditional farming requires 1,000 square meters of land and around 1,160 metric cubes of water. Consequently, the hydroponic systems saved more than 80% of water per year, precisely $\frac{1160-216}{1160} * 100 = 81.4\%$ (USAID, 2017).

Besides all the benefits the HGFI provides in terms of water and land saving, the system is implemented in a low cost and environmentally friendly green energy instead of fossil fuels. Moreover, HGFI resulted in an increase in revenues, growth in economic opportunities, and providence of competitive skillsets to members of underserved communities. Farmers are provided with vocational training and outreach programs to illustrate new farming models in rural areas, explain the additional benefits and cost-benefit ratio of the new hydroponics methods, and connect the farming community and households to financing hydroponic projects. The aim of the training programs and education material is to bridge the gap between conventional and traditional ways of farming to introduce an innovative hydroponic farming method. As mentioned earlier in the paper, developing the farmers' skills would create more efficient and sustainable farming methods while using fewer resources. Furthermore, the target groups would procure enhanced job opportunities and promote entrepreneurship. Participants in the vocational training would learn a new skill that helps them find employment, start a business, and/or become self-reliant (USAID, 2017).

2.3.2. WFP Hydroponics: Untapped Opportunities in Jordan and Algeria

Similar to the project implemented by USAID, the World Food Programme (WFP) has also found a need to implement low cost hydroponic systems in Jordan and Algeria. Many factors such as the scarcity of resources, limited agricultural land, low energy resources, and being a food-deficit country would call for innovative ways of farming, such as hydroponics. According to the report published by WFP, hydroponics has proven to save up to 90% of water resources, three quarters of land space, along with faster production and growth cycles of agriculture output compared to traditional farming. This would "enhance food security through sustainable and efficient resource use, representing a relevant tool for achieving the second SDG of Zero Hunger." (World Food Programme, 2019).

Furthermore, not only are fruits and vegetables grown hydroponically, but also, fresh green fodder can be produced to feed livestock such as goats, sheep, cows, ruminants, horses, chickens, pigs, and other domestic animals. The green animal fodder is produced within seven to nine days with little water and no nutrients or fertilizers. Providing the animals with nutritious barley fodder grown hydroponically, their overall health would enhance (Aden & Artan, 2019).

The hydroponic system has numerous benefits for the farmers as well, in terms of food security, sustainability, community engagement, self-reliance, and improvement in access to nutritious food and dietary diversity. Producing fodder hydroponically to feed livestock animals such as cows would increase the production of milk and their dairy products. When the quality and quantity of dairy products are enhanced the animal's wellbeing is improved, and by translation, the farmer and his family's

nutritional status is improved, specially kids in terms of calcium obtained from fresh milk and dairy products (Safari *et al.*, 2018).

WFP provides training and practices for farmers to address specific challenges they might face and support them in creating a successful business model. Community engagement and self-reliance are performed by participants who generate, build, grow, and develop their assets while decreasing reliance on external aid and becoming more and more independent. Producing fodder could be a potential to provide additional income for food-insecure households. Selling fodder and dairy products to other farmers could generate added income and hence having a positive impact on the farmers' business models (World Food Programme, 2019).

It is important to note that the hydroponic system is designed using locally available materials and resources found within the community, at a low and affordable cost. Therefore, the system is feasible, sustainable, and replicable. To sum up, these hydroponic projects were successfully implemented by WFP in Jordan and Algeria in 2019 and 2018 respectively and has positively impacted their food security levels, nutritional outcomes, as well as improved capacity for households to recover from shocks and stresses (World Food Programme, 2019) & (Safari *et al.*, 2018).

2.3.3. FAO Hydroponics Project in Jordan

Hydroponic agriculture is implementable by small scale farmers and expandable based on their agricultural needs and land availability. In the MENA region, many hydroponic projects are introduced by governmental and international agencies targeted to small scale farmers. In February 2020, The Food and Agriculture

Organization of the United Nations (FAO) and the Ministry of Agriculture (MoA) in Amman Jordan launched a hydroponics and aquaponics water-saving systems project. The project is designed to train farmers and set up an information based and inquire about hydroponics. Participants were able to engage in training, workshops, and implementation. This project has a direct impact on small scale farmers who are saving water resources and land space. According to Alexis Bonte, FAO Representative in Jordan, research shows that in traditional agriculture, every 1 kg of tomato requires 63 litres of water, whereas in hydroponics it only requires 26 litres of water (Food and Agriculture Organization of the United Nations (FAO), 2020). Moreover, the indirect impact of hydroponics on small scale farmers is supporting employment and creating job opportunities. As well as improving the national water security and enhancement of the efficiency of the agriculture sector. In summary, there are many hydroponic projects introduced by international and governmental agencies, such as the examples discussed earlier, targeted to small scale farmers and beneficiaries. By providing them with the skills, resources, and knowledge to implement a hydroponic farming system, participants of the project were able to significantly benefit in terms of increased agricultural output, enhanced quality of the crop, less cost, better work opportunities, and so on.

2.4. The Substantial Positive Impact of Hydroponics on Rural Development

As mentioned previously, hydroponics is a type of agriculture that involves growing plants without soil, by using mineral nutrient solutions in water. It has several advantages such as less water consumption and thus less impact on the environment, greater yield, faster plant growth, healthier plants, and saves space (in case of use of

vertical hydroponic systems). Whether hydroponics is adopted in rural or urban areas they would benefit from the above-mentioned advantages. Hydroponic farms are being adopted in both rural and urban areas as consumer demands for fresh fruits and vegetables with high nutritional value have increased. Hydroponic systems could be set up anywhere since they don't depend on external conditions. In idle or recycled spaces such as parking lots, building rooftops, warehouses, or shipping containers (Verner *et al.,* 2017).

A report by Putra *et al.,* (2018) concludes that three different hydroponics systems such as the Nutrient Film Technique (NFT), Ebb & Flow (tide and low tide), and Fertilization System (fertilizer and drip irrigation system), could widely be used in rural areas. The concept of hydroponics is highly relevant in villages and rural areas, due to problems such as limited land space (where hydroponic systems could be custom built by farmers in their backyards or the remaining uncultivated lands) and due to modification in function and unsustainability of livelihood and traditional farming in the village (Putra *et al.,* 2018).

2.4.1. Impact on Rural Migration

Instead of having people migrate to the urban or peri-urban areas to find employment opportunities, the hydroponic farms implemented in rural areas are a solution to such problems. New economic opportunities and competitive skillsets are provided by hydroponics to vulnerable communities such as women, youth, and the underprivileged in rural areas. New initiatives that demonstrate new farming models in rural areas introduce training-for-employment opportunities, as well as assisting

targeted groups to obtain better jobs and promote entrepreneurship amongst farmers (USAID, 2017).

The interest of the youth in rural areas to become farmers is generally decreasing. One of the issues they are encountering is the reduced agricultural land and lack of farming ability. The introduction of hydroponic systems for rural regions has motivated and persuaded many of the young generations to become independent farmers (Putra *et al.,* 2018). Rural farmers aim to improve their wellbeing through hydroponic systems as an alternative to traditional farming practices.

2.4.2. Impact on Farmers Business Model

The hydroponic techniques, providing greater volumes of value added products, creates an excellent opportunity for farmers based in rural areas to tap into the export market, by targeting specific demands in countries where such produce is not widely available. The farmers would have the ability to rely only partially on the local market, and this would create a business diversification that alleviates the consequences of a potential economic downfall in one market, so long as the farmer is simultaneously relying on demand coming from other markets which different economic conditions. The hydroponic techniques are a tool that opens up for the farmer the opportunity for business diversification by market, by crop, and by types of clients, which ensures resilience and sustainability against downtrends. The partial reliance on external markets is a great opportunity that ensures a constant revenue stream denominated in foreign currency, an asset that proved to be very valuable in the current economic situation of Lebanon. With this foreign currency-denominated revenue stream, the

farmer can ensure its livelihood in the rural areas, expand its business in the rural areas, integrate their business model with other sub-sectors such as packaging and distribution, and sustain a good living standard in the rural area, which on the medium-term, helps maintain the youth's interest in setting up their business plans and activities in the rural areas (Verner *et al.,* 2017).

2.4.3. Impact on Rural Areas Agritourism and Local Economy

Moreover, hydroponic farms can be a great idea for agritourism. The technique implemented is unique and would be of great interest to many visitors. It is a naturally simple, innovative, and advanced technique simultaneously. A variety of people and groups, such as tourists or students would like to experience rural life, interact with farmers, and know more about how and where their food is produced in a modern way. This creates a touristic ecosystem based on innovation in agriculture and thus provides many indirect economic opportunities to the rural areas, as spending of tourists in these areas would increase. Not to mention that farmers could benefit from the opportunity and sell their products on-site. This is an additional source of income for the farmers. Besides, the customer would have delicious produce freshly harvested. Linking the farmer directly to the end consumer, farm-to-table. Last but not least, the farmers can organize explanatory sessions for students from science class who are interested in agriculture. As well, the farmer can arrange tours in the farm, starting from the germination process through the reproduction until the packaging. If customers liked the experience, they would become loyal customers and return to purchase fruits or vegetables (Nelson, 2005).

From the private sector side, what started at the level of hydroponic increased efficiencies, would translate into an increased interest by the private sector to invest in such growing economies. The agritourism aspect of hydroponics is one aspect, where it would drive potential investments in retails, hotels, and restaurants, as well as nature-based tourism investments. But as such businesses grow with the growth of hydroponic farming, the rural areas could shape their services based on their geographical location to play a key role equally in the logistics sector, travel, etc.

2.4.4. Impact on Rural Areas Infrastructure

With the improving local economies that such an enhanced agri-business models would create; the rural areas would require improved connectivity and basic infrastructure services. This is an important bottom-up investment driver that initiates at the levels of the locals and drives demand for such wider investments by the public sector for these rural areas. The government agencies could reap the benefit of improved infrastructure in such areas, when delivering an overhaul and upgrade of the existing infrastructure in such areas, such as roads, water and wastewater networks, solid waste management, and electricity networks. This creates a great basis for the private sector to invest in these rural areas, knowing that connectivity, mobility, and basic services are improving. Such investments by the public and private sector would most definitely increase the local economic value, create a business friendly environment that results in significant improvements in rural business success, and general assets appreciation such as the appreciation in land value in the rural areas. The public sector is an indirect beneficiary of infrastructure investment would capture many additional benefits, starting from the increase in collected tax revenues due to the

increase in business volumes in the rural area, as well alleviate the pressure of rural-urban migration, and maintain social stability and prosperity.

2.4.5. Skills Development of Farmers for a More Efficient Rural Agriculture

Hydroponics introduces only a simple change in the way of agriculture but does rely on the general practices of agriculture used by traditional farmers including the need for sunlight, nutrients, growing media, weather conditions, etc. The simplicity in the required change could signal the ease of introducing such technique to the traditional farmer and indicates that there will be the need for some limited and custom-designed training, so long as the farmer understands the immense benefits that such technique is going to bring to their business model, lifestyle and standard of living in their rural areas, and the impact of such techniques on the rural areas in general. Whether large scale or small scale hydroponic systems are implemented they should complete several steps such as piloting, trials and error, raising awareness, vocational training, and field investigation (Verner *et al.,* 2018). Such training could be self-driven by the farmers themselves using publicly available information on the internet, and by accessing the stories and practices of other similar successful models in other countries or brought about by organizations such as international development organizations and the government agencies under a structure training program with clear objectives, implementation schemes, and monitoring, to the farmer when the internet is not accessible.

Technical training and developmental assistance to small scale farmers, greenhouse producers, and stakeholders, by using centres for demonstrational purposes

and field-level interventions can be used their skills in crop production, harvest budgeting, and market analysis. When properly implemented, such training programs will help in production planning, pest and pollutant management, observation of water resources, developing hydroponic production techniques, shipping, packing, and crop management. Finally, it is necessary to bring into the picture value chain actors to develop trust between producers and marketers. This will allow them to leverage their proposed numbers, reduce costs where possible, as well as capture new market opportunities. Therefore, such policies will strengthen the trust among these actors, their technical skills, how to assess risk, and make proper decisions.

Moreover, cooperatives are an important player that could introduce the concept of hydroponic farming to small scale farmers and train them to adopt it. By informing the farmers about the immense benefits that hydroponics provides and examples of some success stories they would be encouraged to adopt hydroponics. A cooperative is defined as “an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly owned and democratically-controlled enterprise.” (Abouzeid, 2019). Cooperatives assist in providing and procuring goods and services to the members of the group. There are many principles of cooperation such as open and voluntary membership, independence, and autonomy, providing education, training, and information, concern for the community, cooperation between cooperatives, and so on so forth (Abouzeid, 2019). Cooperatives are used by the government and NGOs to extend training and other capacity building initiatives. Agricultural cooperatives could play a major role in providing education and training sessions for farmers about new ideas in agriculture such as hydroponic farming. Some cooperatives offer services to

members as a way of building their capacity. Farmers can receive training on new production techniques, as well as literacy training, or business and marketing building workshops (Dr. Sifa). In addition, cooperatives could also supply farmers with input required for agricultural production, including seeds, equipment, machinery services, and others. Cooperatives also have the potential to provide small scale farmers with access to credit. This will allow the farmers to integrate into the market economy. In rural communities, farming cooperatives are essential to support local communities and their economies. To sum up, cooperatives promote education and opportunities for farmers. Therefore, they could promote hydroponics for farmers and facilitate and support them to adopt the new method of farming, given its numerous benefits for the farmers.

CHAPTER 3

RESEARCH METHODOLOGY

Several methodologies are utilized to make an informed and detailed assessment of the feasibility of implementing hydroponic systems in the fight against food insecurity in Lebanon. These methods range from utilizing capital budgeting methods as well as simulation models to observe the role that hydroponic systems can play in the Lebanese context. Therefore, this paper will follow a qualitative methodology and observe several case studies to understand the systematic approach to the implementation of hydroponic mechanization in the Lebanese context for food security and food shortages. Qualitative data is not capable of being measured. It is descriptive, categorical, and conveys information regarding attributes. It gives the researcher a greater depth of understanding, and an increase in knowledge about the phenomenon of study (Clark, 2008).

The research methodology is directly informed by observing the gaps and shortcomings in previous attempts and research on the topic. Thus, the methodology is based on desk review and secondary data analysis. However, since fieldwork is not possible at the time due to the COVID-19 pandemic, research will be gathered and analysed accordingly. Working from this point, the methodology that guides this research focuses on surveying and studying multiple examples and techniques to enhance the food security and sovereignty. It maps out and analyses different models of hydroponic systems as well as water-saving techniques in agriculture (Verner *et al.*, 2017). By surveying the existing attempts at such programs and methods, I can make use of previous research in order to recommend projects and plans for food sovereignty

by taking into consideration the myriad limitations, shortcomings, and gaps. This dissertation made use of UN and NGO-based grey literature reviews to inquire about the present situation and analyse the impact of food insecurity in Lebanon.

CHAPTER 4

DISCUSSION AND ANALYSIS

4.1. The Changing Agriculture Sector

The whole agricultural industry, including in Lebanon, is facing huge challenges, such as an increase in the costs of supplies, shortage of labor in the agriculture field, high cost of land, rapidly dwindling water resources, and changes in the consumer's preferences and tastes (Mneimne, 2019). Agriculture companies are increasingly recognizing the need for solutions to these problems. During the past decade, governments and institutions have made huge investments in the agriculture sector. Lots of research and development (R&D), as well as testing and experimenting, has been done. New and advanced techniques in agriculture were introduced such as indoor vertical farming (hydroponics and aeroponic), automation and robotics, livestock advancements, precision agriculture, artificial intelligence, Internet of Things (IoT), blockchain, modern greenhouse practices, and many more (Ku, 2020). These systems have rapidly advanced and have changed the way traditional farmers work. Advanced agriculture methods that are presented in hydroponics can address the issue of food security.

4.2. Hydroponics Potential in Lebanon

Lebanon is known to have a varied climate, this implies that the country has several growing areas due to the multitude of sub-climates that can be found in the country, as well as diverse environments. This permits the creation of several opportunities that would develop its greenhouse sector and become more competitive in

terms of its regional capability and international position. Based on this understanding, it would be open to and have access to certain profitable markets in Central Asia, the Gulf States, and the European Union. Nevertheless, for such an improvement, the greenhouse sector in Lebanon must adopt innovative techniques in hydroponics and become an expert in its usage while improving the status of its producers and farmers through a coherent administrative and management system.

Section 2.3 of the literature review mentions case studies of hydroponic farms that were introduced in several MENA countries such as Jordan and Algeria. Lebanon has the same background and similar context in terms of weather, arid and semi-arid regions, agriculture, and food security situation. Therefore, similar hydroponic projects could be implemented in Lebanon with the help of international agencies such as the World Food Programme (WFP), Food and Agriculture Organization (FAO), European Union, and the World Bank, and would yield similar successful results. Adopting the same approach that was used in other MENA countries (Jordan and Algeria) which is introducing a low-cost hydroponic technique to farmers and providing them with training programmes would be beneficial for the farmers, their households, their community, and consequently the country.

In the 1970s, greenhouse agriculture began in the coastal areas in Lebanon. Nowadays, it has been adopted all over the country, in inland and non-coastal areas too. Therefore, protected cultivation has been adopted for decades. These crops could be an entry point for farmers into the hydroponic system. Hydroponics basically generates higher yields of protected crops through more advanced methods of farming. So far, there are a few hydroponic farms in Lebanon today. Based on the Daily Star (2017), a hydroponic farm was built in the northern part of Lebanon with a land size of about 400

square meters. In 2015, the Hyundai Startup Company built this farm, where crops are now growing and extending both vertically and horizontally. Four larger-sized hydroponic producers exist in the country; two of these hydroponic farms are located on the southern coast of Lebanon, and two along the northern coast (Verner *et al.,* 2018). This shows that the hydroponics concept is present in Lebanon and there is a starting point for this innovative agricultural technique that could be expanded in Lebanon.

There are many different types of hydroponic systems, differing in complexity, cost, design, and ways of operation. Several factors are considered when choosing to adopt a certain system, such as the type of crop to be grown, the space limitation, the initial investment cost, and the knowledge of the producer. The range of at least seven different types of hydroponic systems have many similar features, however, they differ in their nutrient solution management, as well as the layout and equipment setup. Farmers could begin with the conceptual layout for an inexpensive, cost efficient, and simple system, using mainly readily available material at their farms, that meets their needs and generates valuable crops for their community (Verner *et al.*, 2017).

There are several notes to be made about Lebanon's agricultural sector, mainly involving underdevelopment, and so there is room for improvement as its industry has yet to realize its full potential. Researchers from the World Bank have shown that new forms of agricultural practices, such as frontier agriculture, can boost the economic and nutritional well-being of farmers, and help to integrate them into the labor market. Frontier agriculture, including hydroponics, is a innovative approach to farming that makes use of systems that save water and are climate-smart. This can be vital not just for average Lebanese farmers, but for a wide network of individuals and groups that are

vulnerable and excluded from the labor market such as the youth, refugees, women, and internally displaced persons (Verner *et al.*, 2017).

This agricultural potential can be realized though the implementation of low-cost hydroponic strategies within the agriculture industry (Markantonis *et al.*, 2019). Knowledge, motivation, and technical applicability would allow the growth of the agriculture industry and with it new farming opportunities. This could be driven by farming methods and techniques that would allow the growth of plants without the use of soil, and so less space or land is needed (Verner *et al.*, 2017).

4.2.1. Land Tenure

Lebanon consists mainly of bumpy mountainous regions with slopping and sharp lands. The land use map of Lebanon issued by Council for Development and Reconstruction (CDR) showed that the major agricultural areas are located in the Bekaa followed by Akkar and South of Lebanon (Nahas, 2004; Darwish *et al.*, 2012). In 2007, the total area of cultivated land in Lebanon was 277,000 hectares (27% of the total land area), of which around 50% was irrigated. Several specialists in the field fear that Lebanon will face a major water crisis soon. In Lebanon, private property of lands is very common and encouraged too. 62% of the total useful agricultural lands have direct tenure. More than 80% of the small farms with less than half a hectare of land has land tenure. However, this decreases for lands with more than 10 hectares of space, constituting 50% of the farms. On the other hand, the leasing of land covers 18% of the useful agricultural surface.

While some farmers have access to direct tenure either by land acquisitions over time or through generational inheritance of properties, it has been challenging for farmers with expansion plans to have sustainable access to new land through direct ownership. This was mainly due to the high investment costs for acquiring land, coupled with limited bank financing for such acquisitions especially after the banking crisis of Lebanon that started in October 2019. This entails that farmers would either have to save aggressively and use their saved capital to buy land, which is sometimes not successful due to the uncertainties and unanticipated needs of the farmer during the farming seasons (such as adverse weather conditions affecting the outcome of a season and thus draining their prior savings), or they would have to resort to land leasing, which generally constitutes a practice of preference for farmers with limited funding sources. However, leasable or sellable agricultural lands are not always available in the farmer's preferred rural locations close to their residence and their operational farms, and a cost-benefit analysis of farming in distant areas where such land is available could indicate that resorting to distant lands may turn out to be uneconomical and unpractical for farmers, as it introduces additional transportation costs, new facilities, and reduced economies of scale (for instance, having to invest in new irrigation systems instead of expanding their existing ones). Hydroponics allows for land use maximization; in a nutshell, farmers with limited farming space and willing to venture into this innovative and simple technique can resort to vertical hydroponics agriculture, with three, four, five, or six layers of agriculture suspended vertically one on top of the other on a stand. This vertical hydroponic solution enables the farmer to produce three, four, five, or six times more crops per square meter of land, compared to traditional in-soil agriculture. In terms of outcome, the result with hydroponics is a multiplication of the production

capacity of one square meter of land, which is a clear solution for farmers with limited access to new land (Darwish *et al.*, 2012).

4.3. Hydroponics Advantages

4.3.1. Resources Efficiency

Hydroponic systems are innovative, effective, and climate-smart methods that create the conditions to make more healthy and nutritious food whilst using significantly less water in the farming process, amounting to a decrease in 80% of water use (Verner *et al.*, 2017). Hydroponic farming is beneficial for the environment and climate. It reduces the impact on natural ecosystems and decreases the environmental and ecological effects by using less water consumption and decreasing the use of fertilizers and pesticides. FAO has determined that, without changes in efficiency, "the world will require 60% more water for agriculture to feed the additional two billion people that are projected to be added to the growing population of the world by 2030." (Food and Agriculture Organization of the United Nations, 2017). This is also the case for Lebanon as the severe water shortage is affecting millions of people's daily consumption as well as farmers. Farmers in the Bekaa valley in Lebanon are struggling to irrigate their crops due to the decreasing water supply and inefficient resource management (Managing Scarce Water in Lebanon's Bekaa Valley, 2020).

Hydroponic farms save between 70% to 90% water than traditional farms, as the water is recirculated and reused (Ku, 2020). Certain nutrients must be added to the water to ensure the crop can grow with the right medium and result in excellent crop quality. Hydroponic systems increase efficiency, sustainability, and serviceability, compared to traditional farming.

4.3.1.1. Rainwater Harvesting

At the core of the challenge of a specific and essential sustainable development route in the Middle East and North Africa region is the relationship between water resources and food security, and this is the case especially for Lebanon. Recent economic, political, and social events around the globe in general, and in Lebanon in particular, have forced many scholars, practitioners, and policymakers to pay specific attention to the reality of food shortages in Lebanon and their impact on food security (Markantonis *et al.,* 2019). This allows us to stress on understanding how the water-food relationship can indeed shape the reality of food sustainability in the region which is shaped by the physical, hydrological, and agricultural conditions, as well as its water-based economic resources, its institutional assets, and its social dynamics (Scardigno *et al.,* 2017).

Soils that are depleted in nutrients, water scarcity, as well as environmental pollution, as mentioned above, continue to be a primary issue and a major challenge worldwide. These 'challenges' will most likely continue to worsen as global populations are set to increase and grow. One way to address the shortage of water for agriculture in rural areas is by adopting low cost and simple water harvesting techniques, such as channelling rainwater from the roof of a house, or a greenhouse, to a water tank, after filtering such water with a thin net to remove solid objects, insects, etc. As fresh water is at the heart of any type of hydroponic system, having access to freshwater via rainwater harvesting can constitute a solution that can be secured from the winter season, to cover temporary water shortages that could happen in any season. This increases the farmer's resilience against any unanticipated cuts in water supplies provided from the grid, or any defect in the underground water-well pumping out

systems that they may have. Ultimately, rainwater harvesting does strengthen the ability of farmers to withstand short term shocks in water supply, and for a hydroponic system, where water is at the core of all the production model, turns out to be a very valuable asset to the farmer.

4.3.2. Production Success Factors

Produce that are cultivated through hydroponic agricultural means are essentially suspended in water solutions as they are enriched with the necessary nutrients for proper growth (Markantonis *et al.*, 2019). By conducting some agriculture practices, nutrient development, and temperature controls, hydroponic farms can easily and competently cultivate any kind of produce, even those that are known not to survive in Lebanon's natural environment.

One of the advantages of hydroponic agriculture is its non-seasonality; meaning that farmers can produce the crop all year long, regardless of the season of the crop by controlling the temperature, light hours, humidity, and nutrients inside the controlled environment (Mneimne, 2019). For instance, the seasons to grow lettuce in Lebanon is in spring and fall, but with hydroponics they can be grown all year long. Not only does hydroponics allow for continuous production throughout the year, but also, more growing seasons and shorter harvesting cycles than traditional farming methods. The growth rate is up to 50% faster than soil-based farming, having the same conditions, depending on the system chosen to be adopted, as well as the type of crop and other factors. Scientists explain the faster growth by providing extra oxygen in the hydroponic medium directly to the roots. Plants would absorb the nutrients faster and

stimulate growth. The water that is circulated among the plants contains the exact nutrients needed and sent directly to the roots. Consequently, this method will substantially improve agricultural production and sustainability.

Hydroponics will lead to higher crop productivity and higher yield, which allows farmers to meet the demand of the Lebanese market, instead of relying on imports. Moreover, since the yield has increased some could be used for local consumption, others could be exported, and this creates an inflow of USD to the Lebanese farmer. As mentioned in the article "Critical Perspectives on Food Sovereignty", Edelman *et al*., question whether local farmers and food producers would be able to keep up with the citizen's demands and preferences. They are doubtful whether agroecological production would be able to feed a growing global population. Similarly, an article published by the Food and Agriculture Organization (FAO) mentions that projections show that feeding a world population of 9.1 billion people in 2050 would require increasing the food production by around 70% from 2005 to 2050 (Food and Agriculture Organization, 2009). Since in hydroponics the plant has exactly everything it needs at all times, such as water, nutrients, and proper climate, therefore, as mentioned in this section, hydroponics production is up to 50% faster than traditional farming.

4.3.3. Value Added Products

Hydroponic farming provides Lebanon with a great tool to address food security. Simultaneously it will also act as a safety net and a solution to the food shortage Lebanon is facing. The crop produced from hydroponics could satisfy

household consumption; hence, decreasing their household food insecurity. Examples of such staples are lettuce, greens, strawberries, tomatoes, and a wide variety of vegetables. Furthermore, fruits and vegetables could produce another value added product. For instance, strawberries can be processed into jam, basil can be processed into pesto, tomato could be transformed into tomato paste, and so on. This culinary activity increases their access to nutritious food. As well as generates income for the family if the products are sold, whether in Lebanon or exported to international markets. Unemployed household members would participate in this activity instead of staying idle. Consequently, their economic status is enhanced. It can also promote entrepreneurship, enhance families' livelihoods, improve cooking skills, and build social cohesion.

Moreover, another benefit of hydroponic systems is that it requires less space, can be used within smaller communities, including businesses, residential areas, and even refugee camps. Hence, vertical farming produces more crops in less area, due to its multiple levels. Christie, 2014, mentioned in the reported "Frontier Agriculture for Improving Refugee Livelihoods: Unleashing Climate Smart and Water Saving Agriculture Technologies in MENA" that the vertical agriculture technique allows crops to be grown in vertically stacked layers which result in increasing productivity with regards to the number of crops grown per square meter (Verner *et al.,* 2017).

According to the authors, in the report "Frontier Agriculture for Improving Refugee Livelihoods" past experiences in small scale hydroponics systems focusing on vulnerable communities can be executed rather quickly and create significant outcomes in a brief time (Verner *et al.,* 2017).

Figure 1: Low cost and affordable hydroponic system for lettuce
Source: (High Tech Gardening, 2020)

4.3.4. Substantial Value-for-Money for Rural Farmers

As indicated in this paper, the investment requirements for such techniques could be scaled according to the farmers need, capabilities, and expansion plans, and could be phased out into several stages while using a portion of the revenue streams generated by the initial phase to finance the expansion of the second phase, etc. In some cases, some financial support could still be needed. While I mentioned in this paper that many materials needed in the hydroponic systems are already readily available in farms, based on the system design that the farmer chooses to adopt, there could be a need to purchase in very limited amounts some additional material/equipment (such as one water pump). In this case, this water pump could be financed by the farmer when affordable and after the farmer realizes the immense value for money for such investment, or by any existing or new grant / loan programs developed to meet the need of farmers, either by international organizations such as the World Bank, USAID, etc or by government agencies. Additional incentives to rural farmers could be established by the government in coordination with such international organizations, to reduce the

import tariff on such equipment, and redesign the fiscal structure that the farmer needs to abide by, such as a subsidized VAT structure, reduced Income Tax, the reduced tariff on exports, etc (Verner *et al.*, 2017).

CHAPTER 5

CONCLUSION

This dissertation provided space to understand how hydroponic systems can be utilized as a solution to food insecurity and promote rural development in Lebanon. Hydroponics provides larger harvest productivity and lower water consumption when compared to traditional farming; this makes it a great answer from the agriculture sector to foster food security**.**

Indeed, the number of studies that are based on the positive and successful performance of hydroponic systems has been consistently increasing. This is mainly because of the innovative and efficient method for the continuous production and reproduction of agricultural crops at a significantly lower cost. It has been clarified throughout the paper that the method of using a hydroponic system leads to diverse developments in terms of technical advancement, cost efficiency, land-utility, and most importantly food security and rural development.

Through this understanding, the design of the hydroponic system provides us with certain techniques in crop production. As mentioned in the paper, at the core of the challenge in actualizing a sustainable development procedure in the MENA region is the relationship between water resources and food security. Therefore, it is suggested that the implementation of a closed system of water recirculation and water management is the best solution to address the challenges related to land availability. This dissertation has demonstrated the implementation and utility of hydroponic systems as a suitable and sustainable technique to address the issue of food security and food sovereignty since they can tackle the challenging issues of agriculture and land

availability. Also, more focus should be placed on accurate and proper farming measures and agronomic practices to boost the efficiency and affectability of hydroponic systems for crop production.

In conclusion, this paper has answered the three research questions that were asked in the introduction. Hydroponics, which is an innovative agriculture technique, could address the issue of the agriculture sector inefficiency and enhance the food security situation in Lebanon. The literature review section on food sovereignty and food security has answered the second sub-question related to the major challenges and issues on the implementation of food sovereignty in Lebanon's current context with the economic and financial crisis, the global pandemic, and the port of Beirut explosion. Last but not least, the hydroponic agriculture could be very beneficial for the development of rural areas in Lebanon.

Further research and investigation are required to dig deeper into the research question and have a holistic approach to how hydroponics can enhance food security in Lebanon.

If the COVID situation permits, I would conduct interviews with farmers, which are the main stakeholders in the agriculture sector, to see their willingness to adopt this new technique. Qualitative interviews and focus group discussions could be conducted with farmers to understand their concerns, beliefs, ideas, and opinions. This focus group discussion will provide the researcher with important insights regarding the group's willingness to adopt new agriculture practices such as hydroponics. One-to-one interviews with farmers will also help me have a deeper explanation and understanding of the food security issue and how to tackle it from an agricultural perspective. The

advantages of interviews are having a flexible format that allows the researcher to explore emotions and create memorable experiences, which would be of added value. Instead of relying solely on secondary data and desk review and analysis, interviews and focus group discussions allow us to gain an in-depth understanding of the issue directly from the original source.

Finally, I will study the government's policies and practices about agriculture and the food security situation. The government plays a major role in promoting new agriculture practices and encouraging local production. If I were to develop this project further, I would look further in the following questions: How is the government supporting local farmers and local production? Is the government reducing VAT on local food producers and/or incentivizing them? Is the government increasing taxes on imports? Does the government have a plan with the help of international organizations to strengthen the agricultural sector, and introduce new techniques such as hydroponics?

All these aspects should be looked further into if I were to continue with this project, as a way forward. Additional studies and efforts should be made to get a clearer understanding if hydroponics is the optimal solution for the issue of food security and sovereignty in Lebanon.

REFERENCES

Abouzeid, G. (2019, October 09). The Role of Cooperatives in Food Security. *General Directorate of Cooperatives* . Beirut, Beirut, Lebanon: American University of Beirut.

Aden, A., & Artan, Y. (2019). *Algeria and Kenya Hydroponic Learning Visit Report.* Algeria: World Food Programme.

Awwad, N. (2020, July 22). *Food Security in Lebanon.* Retrieved April 09, 2021, from https://www.ecomena.org

Babar, Z., & Kamrava, M. (2010). *Food Security and Food Sovereignty in the Middle East.*

Chaifetz, A., & Jagger, P. (2014). 40 Years of Dialogue on Food Sovereignty: A Review and a Look Ahead . *Global Food Security, 3*, 85-91.

Change for Children Learn & Teach Food Sovereignty. (2017). Food Security vs Food Sovereignty: What's the Difference?

Chehayeb, K. (2020, October 09). Beirut Blast Worsens Lebanon's already Concerning Food Crisis. The Tahrir Institute for Middle East Policy. Retrieved February 15, 2021, from https://timep.org

Clark, V. L. (2008). Mixing Quantitative and Qualitative Approaches: An Introduction to Emergent Mixed Methods Research. In *Handbook of Emergent Methods* (pp. 363–387). New York: Guilford Press.

Darwish, T., Chenini, F., & Achouri, M. (2012). *Country Study on Status of Land Tenure, Planning and Management in Oriental Near East Countries.* Cairo: Food and Agriculture Organization of the United Nations (FAO).

Dr. Sifa, C. B. (n.d.). *ROLE OF COOPERATIVES IN AGRICULTURAL DEVELOPMENT AND FOOD SECURITY IN AFRICA.*

Edelman, M. (2014). The Next Stage of the Food Sovereignty Debate. *Dialogues in Human Geography, 4*(2), 182-184.

Edelman, M., Weis, T., Baviskar, A., Borras Jr, S. M., Holt-Giménez, E., Kandiyoti, D., & Wolford, W. (2014). Introduction: Critical Perspectives on Food Sovereignty. *The Journal of Peasant Studies, 41*(6), 911-931.

Food and Agriculture Organization. (2009, October 12). *How to Feed the World 2050.* Retrieved March 13, 2021, from http://www.fao.org

Food and Agriculture Organization of the United Nations (FAO). (2020, February 10). *FAO Regional Office for Near East and North Africa.* Retrieved from Food and Agriculture Organization of the United Nations (FAO): http://www.fao.org

Food and Agriculture Organization of the United Nations. (2017). *The Future of Food and Agriculture - Trends and Challenges.* Rome.

Halabi, S., & Ghanem, N. (2016). *Strategic Review of Food and Nutrition Security in Lebanon.* United Nations Economic and Social Commission for Western Asia (ESCWA).

High Tech Gardening. (2020). *Hydroponics DIY: How to Create Your Own System*. Retrieved April 21, 2021, from https://www.hightechgardening.com/hydroponics-diy-how-to-create-your-own-system/

Hwalla, N., & Bahn, R. (2015). *Assessing and Advancing Food Security in Lebanon: Innovative Initiatives at the American University of Beirut.* Beirut: CIHEAM - International Centre for Advanced Mediterranean Agronomic Studies.

Hydroponic System Basics: The Ultimate Guide for 2021. (2021, March 20). Retrieved from High Tech Gardening: https://www.hightechgardening.com

Jomaa, L., Naja, F., Cheaib, R., & Hwalla, N. (2017). Household Food Insecurity is Associated with a Higher Burden of Obesity and Risk of Dietary Inadequacies among Mothers in Beirut, Lebanon. *BMC Public Health, 17*(10.1186/s12889-017-4317-5), 1-14.

Ku, L. (2020, January 7). *New Agriculture Technology in Modern Farming.* Retrieved March 14, 2021, from https://www.plugandplaytechcenter.com

Leventon, J., & Laudan, J. (2017). Local Food Sovereignty for Global Food Security? Highlighting Interplay Challenges. *Geoforum, 85*, 23-26.

Longfield, J. (2010). *Food Justice - The report of the Food and Fairness Inquiry*. Brighton: Food Ethics Council.

Managing Scarce Water in Lebanon's Bekaa Valley. (2020). Retrieved from Anera: https://www.anera.org/

Markantonis, V., Reynaud, A., Karabulut, A., El Hajj, R., Altinbilek, D., Awad, I. M., . . . Bidoglio, G. (2019). Can the Implementation of the Water-Energy-Food Nexus Support Economic Growth in the Mediterranean Region? The Current Status and the Way Forward. *Frontiers in Environmental Science, 7*(84), 1-11.

McIntyre, L. N., Glanville, T., Raine, K. D., Dayle, J. B., Anderson, B., & Battaglia, N. (2003). Do Low Income Lone Mothers Compromise their Nutrition to Feed their Children? *CMAJ, 168*(6), 686–691.

Mneimne, M. (2019). *Hydroponics in Lebanon.* Beirut.

Nahas, C. (2004). *Schéma Directeur d'Aménagement du Territoire Libanais.* Beirut. Retrieved from Amenagement et Urbanisme: http://www.charbelnahas.org/

Nelson, R. L. (2005). *Aquaponics And Agritourism.* Retrieved April 9, 2021, from Nelson Pade - The Most Trusted Name in Aquaponics: https://aquaponics.com/

Putra, E. S., Jamaludin, J., & Djatmiko, D. M. (2018). Comparation of Hydroponic System Design for Rural Communities in Indonesia. *Journal of Arts & Humanities, 7*(9), 14-21.

Safari, E., Brahim, T., & Bakar, H. (2018). *Hydroponics in the Sahrawi Refugee Camps - Growing Food in the Desert.* Sahrawi: World Food Programme.

Scardigno, A., Capone, R., El Bilali, H., & Cardone, G. (2017). Water-food security nexus in Middle East and North Africa Region: an exploratory assessment. *New Medit*, 31-38.

Sewell, A. (2020, August 11). *In Post-blast Lebanon, Farmers Struggle as Food Shortages Feared.* Retrieved February 15, 2021, from https://www.thenewhumanitarian.org

Stella, G., Coli, R., Maurizi, A., Famiani, F., Castellini, C., Pauselli, M., . . . Menconi, M. (2019). Towards a National Food Sovereignty Plan: Application of a New Decision Support System for Food Planning and Governance. *Land Use Policy, 89*, 1-11.

The World Bank. (2020, April 21). *Targeting Poor Households in Lebanon.* Retrieved December 14, 2020, from https://www.worldbank.org/en/news/factsheet/2020/04/21/targeting-poor-households-in-lebanon

United Nations. (2019). *The Sustainable Development Goals Report 2019.* New York: UN (United Nations).

United Nations World Food Programme. (2020). *Assessing the Impact of the Economic and COVID-19 Crises in Lebanon.* Beirut: UN - WFP.

USAID. (2017, May 24). *USAID Hydroponic Green Farming Initiative (HGFI).* Retrieved March 21, 2021, from https://www.usaid.gov

Verner, D., Ashwill, M., Christensen, J., Mcdonnell, R., Redwood, J., Jomaa, I., . . . Treguer, D. (2018). *Droughts and Agriculture in Lebanon: Causes, Consequences, and Risk Management.* Washington DC.: World Bank Group.

Verner, D., Vellani, S., Klausen, A.-L., & Tebaldi, E. (2017). *Frontier Agriculture for Improving Refugee Livelihoods: Unleashing Climate Smart and Water Saving Agriculture Technologies in MENA.* Washington, DC.: World Bank.

Wood, D., Boswall, J., & Halabi, S. (2020). *Going Hungry: The Empty Plates and Pockets of Lebanon.* Beirut: Triangle.

World Bank. (2007). *World Development Indicators 2007.* Washington, DC.: World Bank.

World Food Programme. (2019). *H2Grow: Hydroponics– Untapped Opportunities.* Amman.

World Food Summit. (1996). Rome Declaration on World Food Security. Rome: FAO - Food and Agriculture Organization.